COUNTY OF SANTA BARBARA
CALIFORNIA

Energy Conservation Element

Santa Barbara County Comprehensive Plan

SANTA BARBARA COUNTY

COMPREHENSIVE PLAN

ENERGY CONSERVATION ELEMENT

Adopted by
Santa Barbara County Board of Supervisors
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APCD	Air Pollution Control District
AQAP	Air Quality Attainment Plan
ARB	Air Resources Board
BCF	Billion Cubic Feet
BTU	British Thermal Unit
CEC	California Energy Commission
CPUC	California Public Utilities Commission
DOE	Department of Energy
EOR	Enhanced Oil Recovery
EPA	Environmental Protection Agency
KWH	Kilowatt Hour
LPL	Lompoc Power and Light
MCF	Thousand Cubic Feet
MMCF	Million Cubic Feet
MSW	Municipal Solid Waste
MSU	Municipal Solar Utility
MW	Megawatts
NEA	National Energy Act
OPEC	Organization of Petroleum Exporting Countries
PG&E	Pacific Gas and Electric
SCE	Southern California Edison
SCG	Southern California Gas
SDP	Solar Development Program
VAFB	Vandenberg Air Force Base

INTRODUCTION

California state law does not require the adoption of an Energy Conservation Element as part of a local Comprehensive Plan. Although not mandated, local governments are given the opportunity to adopt "Such additional elements dealing with other subjects which in the judgment of the planning agency relate to the physical development of the city or county." (Government Code Section 65303 k).

Evidence abounds that energy, and therefore an Energy Conservation Element, relates to the "physical development" of the county. The 1973-74 Arab oil embargo, periodic shortages of natural gas, the prospects of electrical energy shortages, and the 1979 energy crisis have all served as reminders of the importance of energy. Regardless of one's views on the <u>causes</u> of these problems, the <u>effects</u> on community life are clearly adverse. It is the overriding purpose of this study to explore the ways in which the County of Santa Barbara can minimize these local effects by reducing the dependence on conventional energy resources. A successful program to reduce consumption of conventional energy sources and increase the use of renewable resources will not only minimize the disruptions to community life attending any future energy shortages, but can contribute to state and federal efforts to promote energy conservation and renewable resource technologies.

Seeking answers to the energy question is not a new endeavor for the County of Santa Barbara. For some time the community has grappled with the difficult issues accompanying a variety of conventional energy projects. With the adoption of the Conservation Element and the Air Quality Attainment Plan, the county has accepted the commitment to encourage conservation and the obligation to consider more specific recommendations included in those reports. The Land Use Element contains additional suggestions for local government energy planning.

Most importantly, the county recently became the second local government in the nation to <u>require</u> the use of solar energy by mandating the installation of a solar water heating system with every new swimming pool, and a portion of new homes. Although these ordinances will not have a significant effect on future energy conservation, they demonstrate the opportunities for assertive local action.

The Energy Conservation Element is an attempt to build on existing ordinances and previous studies, and establish a solid foundation for energy conservation and the use of renewable resources. The recommended actions, summarized in Part III of the Energy Conservation Element, constitute a set of options designed to promote energy conservation/ renewable resource use through local initiative.

Part I provides a breakdown of current energy use. The major consuming sectors are residential, commercial (including govermental), industrial and agricultural. Within each sector, further distinctions are made between different sub-categories(e.g., single-family and multi-family dwelling units), and selected end uses of energy (e.g., hot water heating, space heating,pumping, and lighting). The disaggregation of energy consumption by sector into the sub-categories and end uses is an important step in determining the local potential for energy conservation and renewable resource development.

Part II provides an evaluation of the potential for energy conservation and renewable resource development in Santa Barbara County. This portion of the study is divided into three main sections;1) energy conservation through reducing the level of wasted energy;2) conserving energy by converting wastes into energy; and 3) renewable resources. In each case, the local potential is defined in terms of the opportunities and constraints associated with conservation/renewable resource approaches and technologies. Opportunities are discussed in terms of both technological feasibility and the effects of state and federal programs. In most cases, the constraints are influenced by economic and institutional considerations.

The local potential for energy conservation and renewable resource usage is summarized in the concluding section of Part II. To illustrate the close relationship between energy technology and govermental policy, two scenarios for future energy consumption in the county are outlined.

The appendices, Part IV of this study, contain a more detailed set of tables, assumptions, and technical information.

It is important to clearly state the limitations of the Energy Conservation Element. The study is limited in scope. All consumption estimates are based on the energy consuming activities in the <u>unincorporated</u> areas only. A second limitation concerns the emphasis on non-transportation energy consumption. Consumption of energy for transportation, primarily the private automobile, is a significant energy consuming activity. Yet the complexities of transportation sector consumption and the policy options for local government to address the issue are substantial enough to warrant a separate study. In those areas where non-transportation energy planning issues overlap with transportation issues (such as land use planning), the relationship will be noted.

A final limitation arises from the problems inherent to energy planning: in an effort to understand the nature of energy consumption and to make judgments about future energy needs, a considerable amount of data has become avilable from government agencies, the energy companies, and private research groups. The trend has been towards increasingly specific and quantitative assessments of many aspects of the energy situation. The attempt to collect and make available quantitative assessments about energy is laudable, but not without limitations. Energy consumption (past, current, and future) is in such a state of flux that any particular quantitative statement is subject to a certain margin of error. The appearance of precision and authority often attributed to data should be tempered by the recognition that there are few hard facts and quite a few opinions stated in statistical form.

The data incorporated into the Energy Conservation Element is no exception to the limitations of using quantitative material. Every effort has been made to fully document the source of all data and to explain the assumptions and judgments which accompany the data. Nevertheless, it is recognized that the quest for statistical precision is an ongoing effort.

PART I: CURRENT ENERGY CONSUMPTION PATTERNS

Effective energy planning begins with a comprehensive assessment of baseline energy consumption. It has been clear for some time that energy plays an essential role in modern day life. Yet it is only in recent years that serious efforts have been made to accurately determine the ways in which energy consumption interacts with daily activities. Any attempt to make these determinations is complicated by the fact that patterns of energy consumption can vary greatly within the United States and within the state of California. As will be shown later in this section, significantly different patterns exist even within the county of Santa Barbara. To facilitate the assessment of local energy consumption patterns, it is useful to determine the types of energy consumed, the amounts consumed, and the purposes of this consumption.

TYPES OF ENERGY

Almost all of the non-transportation energy consumed in the county is in the form of either natural gas or electricity. Natural gas is locally produced, usually in conjunction with the oil field operations in the Santa Barbara Channel and the North County. Gas from local fields is piped into the large distribution and storage facilities of the Southern California Gas Co. (SCG). Once SCG purchases the gas from local producers, it becomes a small part of the SCG system. Most of the gas for the SCG system and therefore the county, comes from Texas via the El Paso Gas Company's pipeline to southern California.

As a privately-owned utility, SCG operations are subject to regluation by state and federal agencies. Decisions on how much gas is delivered to which types of customers and at what prices are, for the most part, subject to approval by the California Public Utilities Commission (CPUC) or the U.S. Department of Energy (DOE).

The electricity consumed in the county is provided through a much larger and more complex supply network. In the unincorporated areas of the county, electricity is supplied by two large, privately-owned electric utilities -- Southern California Edison (SCE) and Pacific Gas and Electric (PG & E). The southern part of the county lies in SCE's service territory, while PG & E supplies electricity to the North County. The City

of Lompoc owns and operates a municipal utility, Lompoc Power and Light (LPL). LPL purchases its electricity from PG & E, and sells it to residents in the city.

Electricity is actually a secondary form of energy, meaning primary energy sources are required to generate it. In the case of PG & E and SCE, the primary energy required to generate electricity is a combination of oil, natural gas, hydro, coal, geothermal, and uranium (nuclear). The mix of primary energy sources varies from year to year, and each utility has its own mixture of power plants. In general, oil and gas are the major sources of primary energy for both PG & E and SCE; hydroelectric and geothermal constitute a larger portion of PG & E capacity than SCE. Nuclear energy provides a small portion of electricity generation for both SCE and PG & E. Each primary energy source for both utilities is characterized by separate sets of geographical origin, conversion processes, and transmission facilities. Electricity purchased from PG&E and SCE by local customers is generated and transmitted to the county by a large network of power plants and transmission lines located throughout California and western United States. The only electrical power generation facility located in the county is a small, infrequently used power station in Goleta. The oil, gas, uranium, hydro, and coal primary sources originate in California, western U.S., and foreign countries. A more detailed breakdown of the characteristics of the utility generation systems is provided in Appendix A.

As with SCG, PG&E, and SCE, supplies of electricity to the county are subject to CPUC and DOE regulation. In addition, many of the supply options of the electric utilities are regulated by the California Energy Commission (CEC).

AMOUNTS OF ENERGY

Any quantitative assessment of energy consumption patterns necessitates a description of how energy consumption is measured. Units of measurement for energy can be very confusing, yet some level of familiarity is essential for energy planning.

Natural gas consumption is usually measured in either cubic feet or therms "Cubic feet" is usually used when large quantities of gas are involved, whereas therms are more common when the point of reference is an indi-

vidual household. For example, total county natural gas consumption is currently about 9 BCF (billion cubic feet; MMCF = million cubic feet, and MCF = thousand cubic feet). A therm is equal to approximately 100 cubic feet and is most commonly used to measure consumption of an appliance or a household -- a typical natural gas water heater in the county, for example, will consume about 260 therms per year.

Electricity consumption is usually measured in kilowatt hours (kWh). A kilowatt hour is the amount of electricity (measured in watts) consumed by an electrical appliance in one hour. A one hundred watt light bulb burning for ten hours will consume one kWh. An electric hot water heater in a single family home in the county might consume 5,000 kWh each year. Total county electricity consumption for all uses is currently about 960 million kWh/yr.

Electricity consumed to operate appliances constitutes a certain level of demand on the power supply system. The network of power stations has to have the capability, or capacity, to supply the demand. The capacity of an individual power plant or supply network is usually measured in "megawatts" (MW, or million watts). A typical conventional power plant has a capacity of about 1,000 MW, meaning it can supply one billion watts of electricity when it is operating at full capacity.

Since the demand for electricity fluctuates according to the time of day and the season, the capacity of a power supply system must be at least as great as the electricity required at the time of highest demand. In California, the highest demand (or "peak" demand) is likely to occur in the afternoon of a very hot summer day when air conditioners are in full use and industrial demand is high.

For purposes of comparing capacity (megawatts) to demand (kilowatt hours), in 1978 the PG&E and SCE systems had a combined capacity of about 30,000 MW and generated about 125 billion kWh worth of electricity. This constitutes more than 100 times the amount of electricity consumed in the county.

Cubic feet, therms and kWh are often converted to yet another form of energy measurement, the British Thermal Unit (BTU). The BTU is a measurement of heat and is therefore useful for purposes of combining or

or comparing energy use of different forms (electricity, gas, solar). For example, total county natural gas consumption and total electricity consumption can both be converted to BTU's. To convert natural gas in cubic feet to BTU's, SCG uses a conversion factor of 1,075 BTU/cubic ft., reflecting the average heat content of locally consumed natural gas. This means that total county gas consumption of 9 billion cubic feet is the equivalent of 9,700 x 10^9 (billion) BTU's. A therm of natural gas is converted to BTU's using a factor of 100,000 BTU/therm; the 260 therms consumed by a water heater is the equivalent of about 2.6 million BTU's.

Determining the BTU, or heat value, equivalent of electricity is more problematic. When the switch on an electric-resistance space heater is turned on, it usually radiates heat into the room at the rate of 3,413 BTU/kilowatt hour of use. If all electrical use in the county is converted to a BTU equivalent at this rate, total county electric consumption amounts to 3,300 x 10^9 BTU's. However, a considerable amount of energy is required to generate and transmit the electricity before it is made available at the point of use. If the wasted energy associated with the burning of primary energy sources in the power plants is included as part of the heat value of a kWh worth of consumption, the conversion factor of about 10,500 BTU/kWh is usually used. The 960 million kWh of electricity consumed in the county is responsible for both the energy used at the point of consumption and the wasted energy at the power plant. Using the 10,500 BTU/kWh conversion rate, total county electricity consumption equals approximately 10,100 billion BTU's, less than one-third of which is actually "consumed" in the county.

In sum, the determination of the amounts of energy consumed in the county is not a straightforward matter. For reasons discussed above, the following considerations comprise the basis for quantifying energy consumption in the county:

- current natural gas consumption figures are based on sales of gas by SCG to customers in the unincorporated areas; conversion to BTU's is based on 1,075 BTU/cf and 100,000 BTU's/therm;

- current electricity consumption figures are based on sales of electricity by PG&E and SCE to customers in the unincorporated areas; conversion to BTU's is based on 10,500 BTU/kWh;

- current total county energy consumption in the unincorporated area for non-transportation purposes is about 10.8 trillion BTU's, 49% of which is consumed in the form of natural gas and 51% electricity.

END USE CONSUMPTION

The final, and most important, aspect of energy consumption patterns is a determination of how natural gas and electricity are currently being used.

Utility compani.. and regulatory agencies have historically categorized sales, and therefore consumption, by sector. Residential, commercial, and industrial sectors are invariably used; sometimes governmental and agricultural sectors are reported separately.

For purposes of this study, energy consumption in four sectors -- residential, commercial, industrial, and agricultural -- will be examined.

If Vandenberg Air Force Base consumption (classified as governmental) were included in the study, then the governmental sector would be a significant category. Because activities at VAFB are largely outside the scope of county influence, VAFB consumption is not included in county energy consumption assessments. Governmental energy consumption outside of VAFB is small enough that specific references to the governmental sector will be made only in conjunction with specific programs. Generally, energy consumption in the government sector is similar to commercial sector consumption.

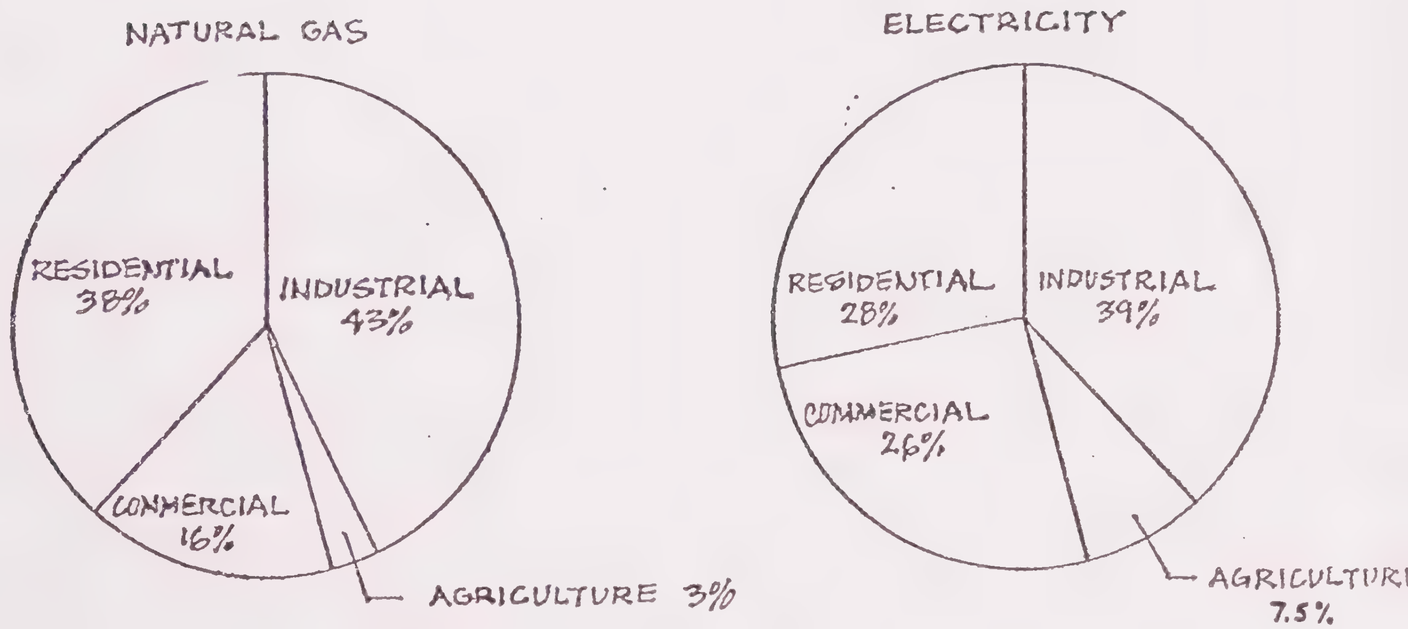
Figures I and II show the distribution of energy consumption for each sector and each type of energy.

The breakdown by sector may suggest general uses of energy, but further disaggregation into specific end uses is necessary. Any serious attempt to evaluate the potential for energy conservation and renewable resources (Part II) and to develop a program to fulfill that potential (Part III) is contingent upon a reasonable estimation of the end uses within each sector.

The end use approach to energy planning is relatively new. Unless stated otherwise, estimates of local end use energy consumption are derived from recent studies of the California Energy Commission (CEC). In

FIGURE I

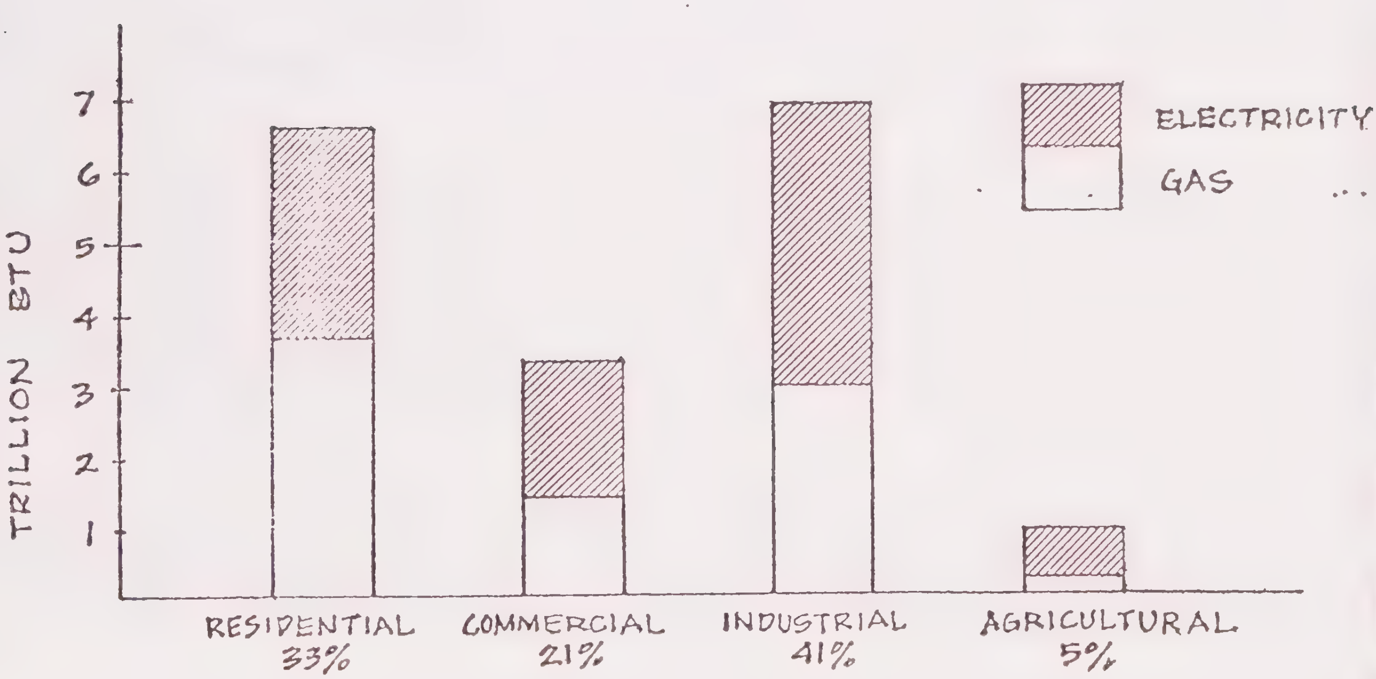
NATURAL GAS & ELECTRICITY CONSUMPTION BY SECTOR



SOURCE: TABLE II, APPENDIX A

FIGURE II

BTU EQUIVALENT CONSUMPTION BY SECTOR



SOURCE: TABLE II, APPENDIX A

most cases, the CEC studies are based on information from California utilities and private studies. The assumptions, calculations, data and specific references used in determining Santa Barbara County end use estimates are found in Appendix A of the Energy Conservation Element.

Residential Sector: Of the four energy consuming sectors, information on the residential sector is the most complete. Although a more thorough assessment of residential consumption would be aided by county-specific surveys, existing information is sufficient to make resaonable estimates.

A number of factors influence the amount and type of energy consumed in a residential structure. The most important factors are:

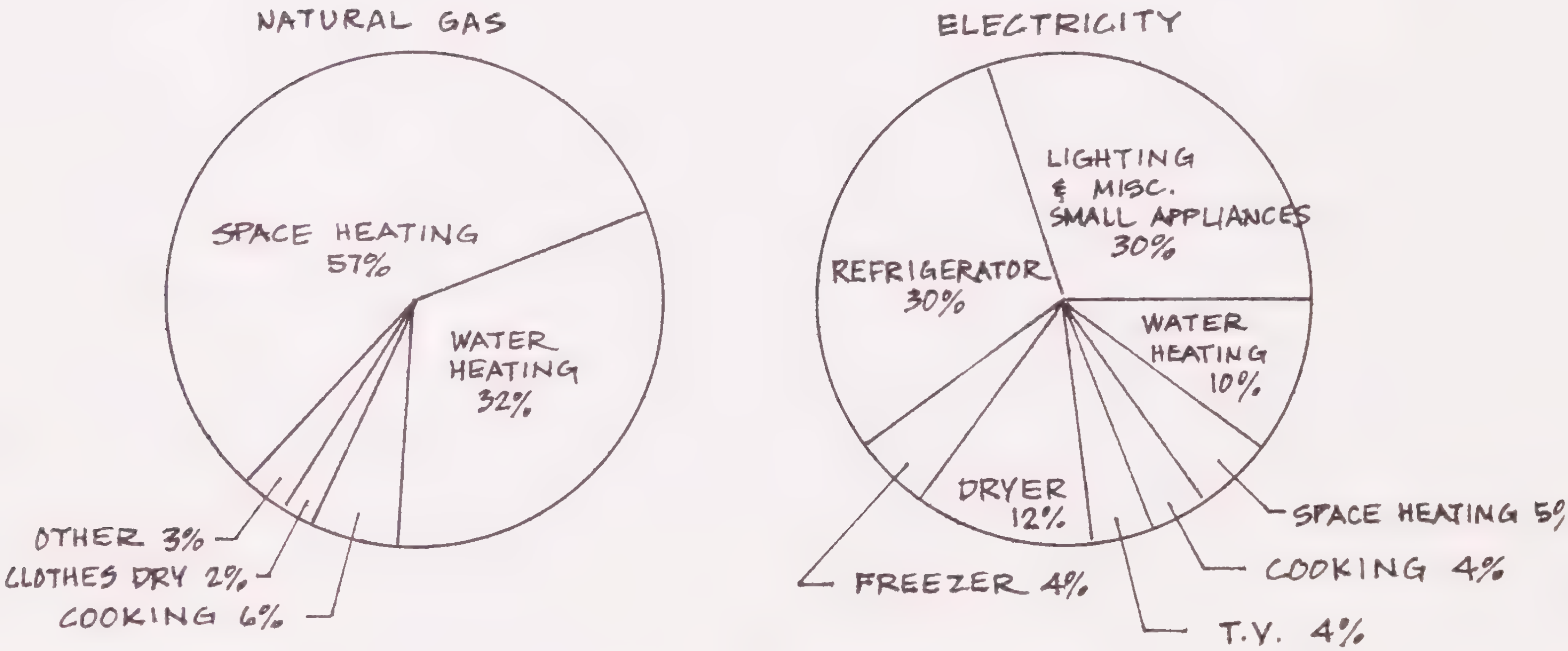
- the type of dwelling unit
- the size of the structure
- the number of occupants
- the habits of the occupants
- the time of year
- the weather conditions of a particular year
- the thermal integrity of the building (level of insulation, number and location of windows, quality of weatherstripping and overhangs)
- number of appliances (washing machine, clothes dryer, swimming pool)
- type of appliances (gas vs. electric heaters, ranges)
- micro-climate considerations (location within the county, the number, placement, and types of vegetation)

Total residential energy consumption in the county amounts to about 6.6 trillion BTU's (33% of the total for all sectors). About 58% of residential energy consumed is in the form of natural gas, with electricity responsible for the remainder.

In some cases gas or electricity may serve the same function in different homes. Space and hot water heating, cooking, and clothes drying can be accomplished with either gas or electric appliances. Lighting, television, radio, and refrigeration are most likely dependent on electricity.

Figure III shows the major end uses of residential natural gas and electricity in the county.

FIGURE III
RESIDENTIAL USES OF NATURAL GAS & ELECTRICITY



SOURCE: TABLE III, APPENDIX A

Of all the factors influencing residential energy consumption in the county, two are the most important - the type of house (single-family or multi-family), and the number of major appliances. To illustrate these differences, Figure IV shows the approximate energy consumption by end use for 4 generic types of dwelling units.

Several aspects of Figure IV need further explanation. The reason multi-family homes are less energy consuming than single-family homes is not just because apartments are smaller. By definition, multi-family units share at least one common wall with an adjoining unit, thereby reducing the amount of heat loss from a space heater. Additionally, multi-family units usually have fewer (and smaller size) appliances, and fewer occupants to use the appliances.

Second, existing all-electric single family and multi-family dwelling units were usually built with better attic and wall insulation. Although more recent building codes require more insulation for all new homes, the existing stock of all electric units tend to have greater thermal integrity than gas homes.

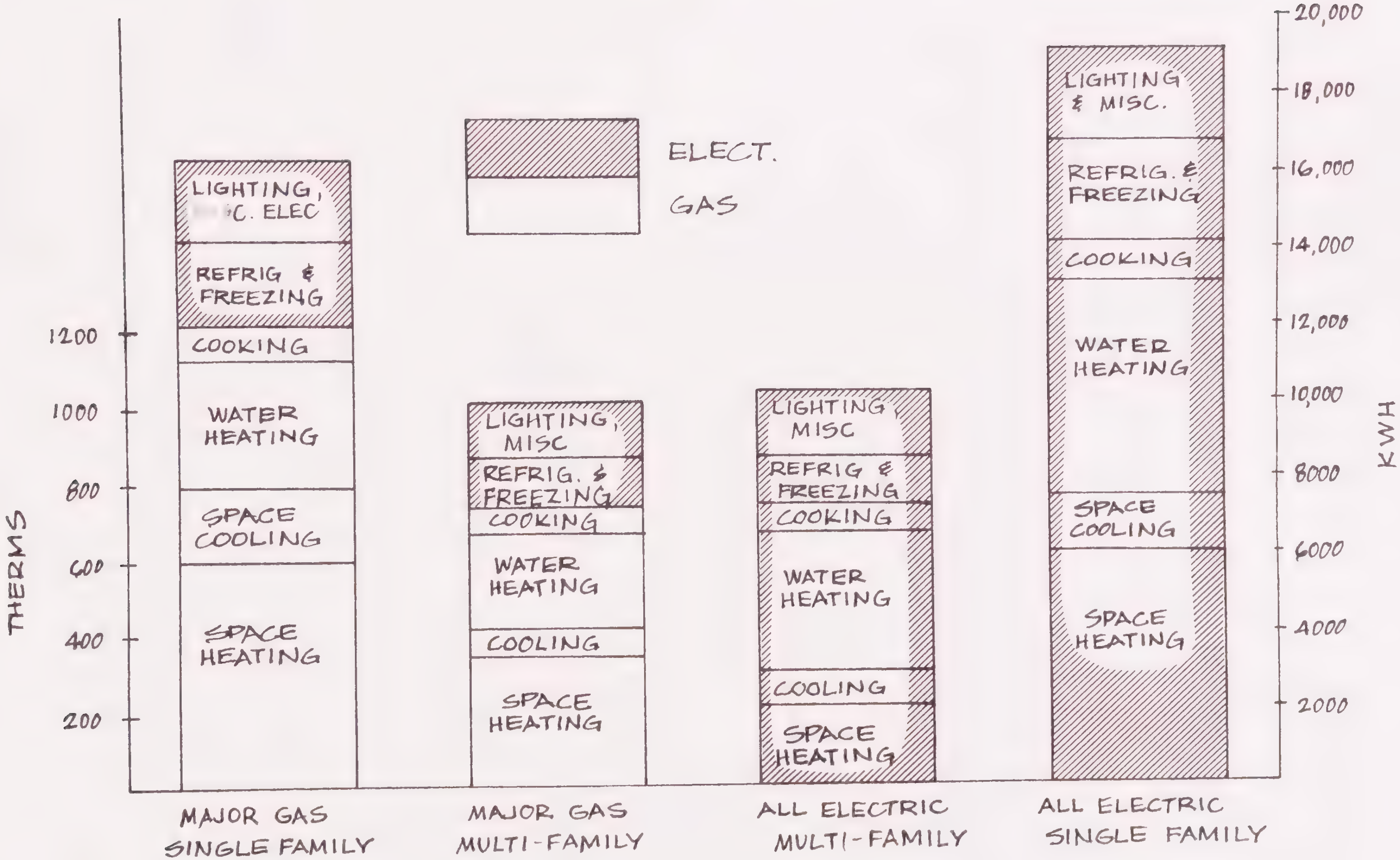
Third, the figures for each type of structure are based on averages. Since the average includes a wide-range of houses built at different times, and therefore include a mix of uninsulated, partially insulated, and well insulated dwelling units, the "average" house is not necessarily a "typical" house.

In order to estimate energy consumption by end use for all residential structures, it is necessary to determine the number of appliances being used in each type of dwelling unit, the type of energy used by each appliance, and the amount of energy consumed by each appliance. Converting natural gas and electricity consumption to BTU equivalents provides the combined consumption of gas and electricity for each end use. Figure V, which accounts for about 98% of residential energy, shows the end use distribution.

The end use assessment of residential energy consumption leads to several important conclusions:

1) Even in the moderate Santa Barbara County climate, space heating is by far the most energy consuming activity, accounting for more than one-third of residential energy consumption;

FIGURE IV
HOUSEHOLD CONSUMPTION
BY DWELLING UNIT TYPE



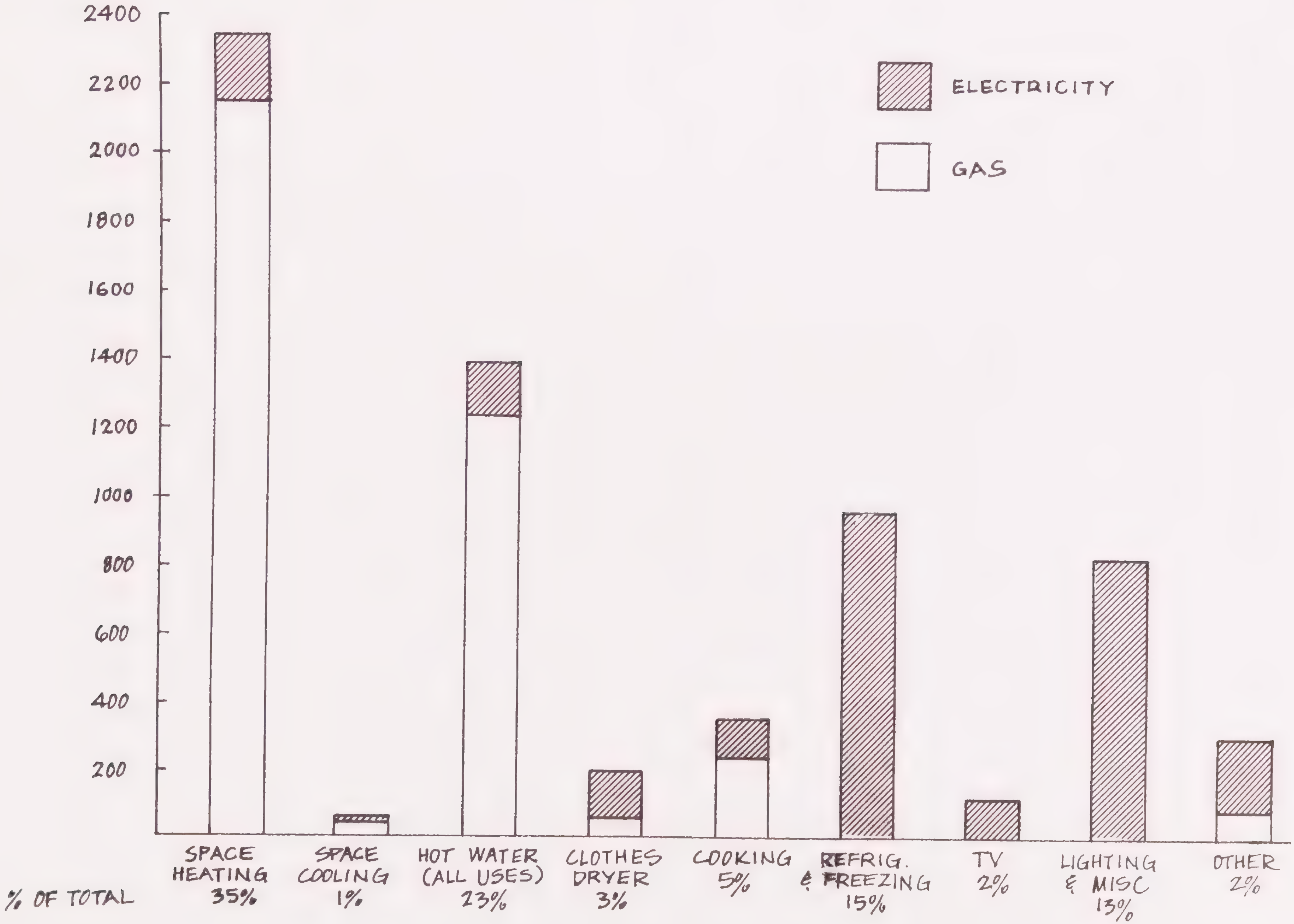
(WATER HEATING INCLUDES DISHWASHER & LAUNDRY)

SOURCE: TABLE IV, APPENDIX A

FIGURE V

MAJOR RESIDENTIAL SECTOR END USES

(BILLION BTUS)



SOURCE: TABLE V, APPENDIX A

2) Hot water heating, the second most energy consuming activity, constitutes almost one-quarter of residential energy consumption;

3) Most (almost 90%) of residential space and water heating consumption is in the form of natural gas.

The implications of these three conclusions will be made clear in subsequent discussions of energy conservation and renewable resource potentials in the county.

Commercial Sector: In contrast to residential consumption, commercial operations consume more electricity than natural gas. The uses of energy in the commercial sector are similar to residential uses, yet the relative importance of the end uses and proportional use of gas and electricity constitute a different pattern of consumption.

The different uses of electricity and gas are influenced by the type of commercial operation. Figure VI shows the natural gas and electricity requirements of eight major commercial building types.

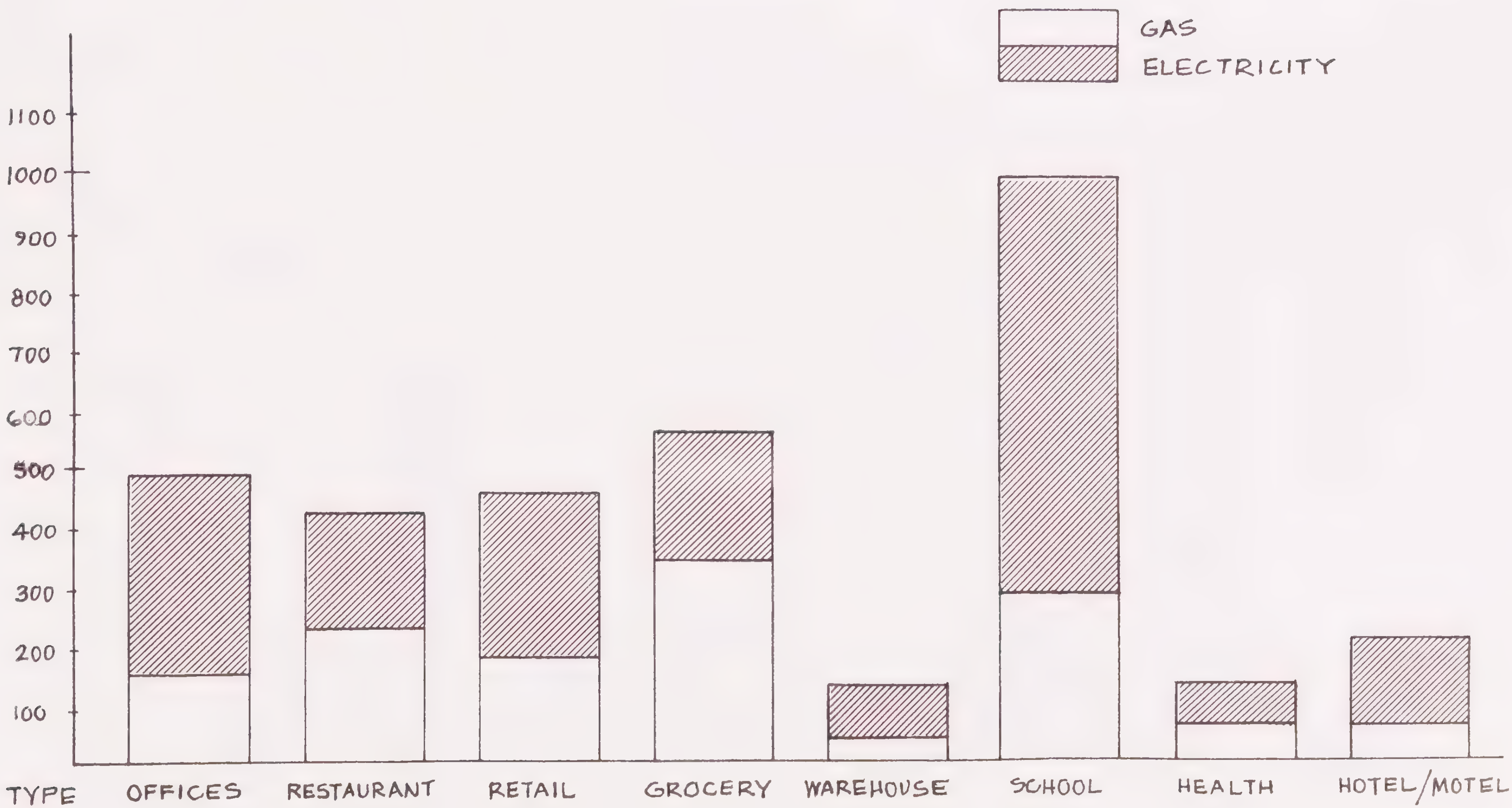
The largest commercial category is "schools," reflecting the relatively large amount of energy consumed at the University of California, Santa Barbara (UCSB).

Each particular building type is characterized by the specific end uses of electricity and gas. With a few exceptions, the major use of electricity for all commercial building types is for lighting, constituting between one-fourth and three-fourths of electricity consumed in each building type. Air conditioning is the second largest electrical end use for all building types except grocery stores. The large refrigeration operations in supermarkets are usually run by electricity and dominate electrical usage in grocery stores.

The major use of gas for all building types is space heating. Since many commercial buildings use natural gas for air conditioning, space cooling generally constitutes a second major use of gas in all building types.

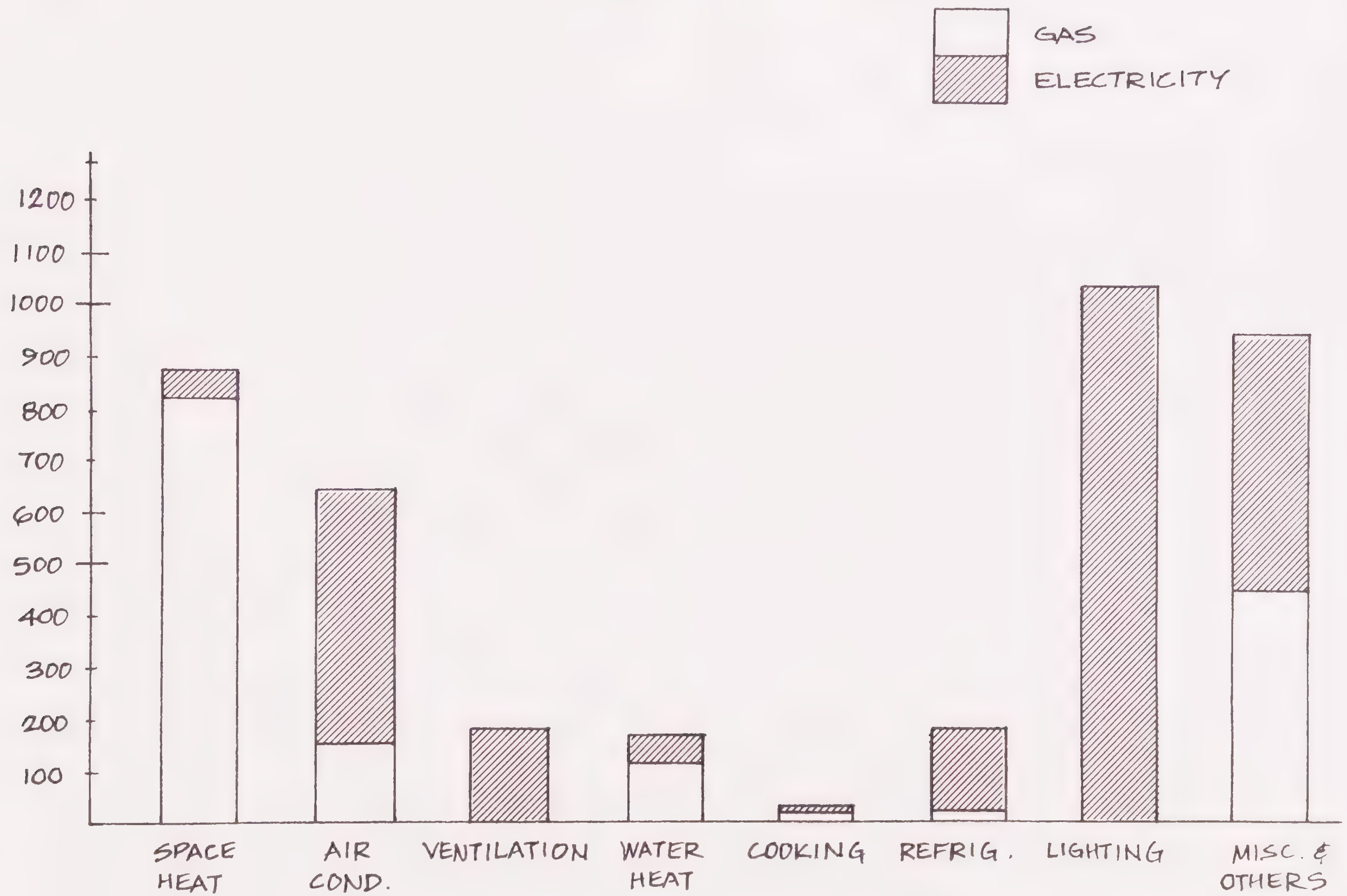
Figure VII shows the complete breakdown (all building types combined) by end use.

FIGURE VI
COMMERCIAL CONSUMPTION
ELECTRICITY & NATURAL GAS
BY BUILDING TYPE
(BILLION BTUS)



SOURCE: TABLE VI, APPENDIX A

FIGURE VII
COMMERCIAL END USE OF
GAS & ELECTRICITY
(BILLION BTUS)



SOURCE: TABLE IX, APPENDIX A

Industrial Sector: In contrast to energy consumption in the residential and commercial sectors, industrial patterns of energy consumption depend upon the specific type of industrial operations. This is particularly true in Santa Barbara County, where a handful of industries dominate energy consumption.

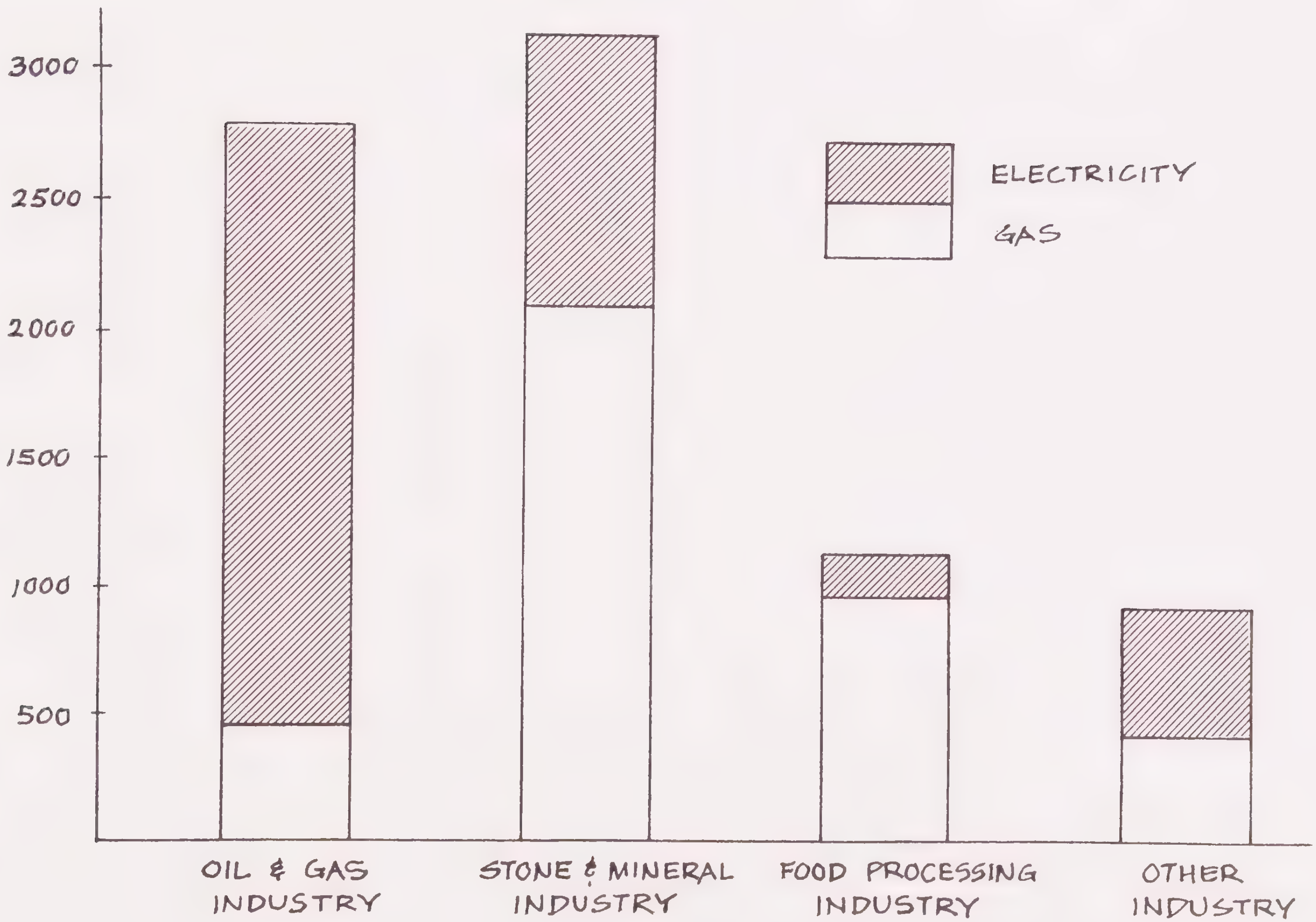
Three industrial groups account for approximately 90% of the local industrial energy consumption. Figure VIII shows the prominent role of the oil and gas industry, the stone and mineral industry, and the food processing industry, and the comparative use of electricity and natural gas. An estimate of the uses of electricity and gas in these industries must account for the energy consuming activities of each group.

The oil and gas industry is heavily dependent on electricity to extract, transport, and process locally produced fossil fuels. Most of the oil operators in the North County and along the South Coast purchase electricity from either PG&E or SCE to operate the well pumps to extract and move the oil to treatment and storage facilities. The more remote oil platforms in federal waters in the Channel, and a few onshore operations, generate electricity with on-site equipment.

Most of the crude oil produced in the South Coast and a portion of North County crude is pumped to ships for transportation to refineries in the Los Angeles or San Francisco areas. Some of the North County oil is transported by truck to refineries outside the county, but a large portion of North County oil is transported to the Douglas refinery operations near Santa Maria. Since this crude is generally very heavy (highly viscous) and contains comparatively large amounts of sulfur, the refinery converts most of the crude to low quality products (asphalt). Refinery operations also require electricity, accounting for a significant portion of the oil and gas industry electricity consumption shown in Figure VIII.

Oil and gas industrial operations also require natural gas and other fuels. The 430 million cubic feet of gas shown in Figure VIII is used primarily to heat the heavier crudes to facilitate pipeline transportation and for the thermal requirements of the Douglas refinery operations.

FIGURE VII
INDUSTRIAL ENERGY CONSUMPTION
(BILLION BTUS)



SOURCE: TABLE X, APPENDIX A

Not shown in Figure VIII is the large amount of natural gas used in the crude oil extraction process for the very heavy crude produced in the Cat Canyon fields. Oil in that region is so "thick" that it is necessary to inject steam in the wells to make the oil flow. In most cases natural gas from the same or nearby oil reservoir is extracted and burned in large steam boilers to produce the steam for injection. At least 5 billion cubic feet of gas per year is currently consumed for the purpose of steam injections, a process often referred to as enhanced oil recovery. Since the field gas used for oil recovery is frequently of such low quality that it is not saleable, field gas consumption is not strictly comparable to the natural gas used elsewhere in the county. For comparing energy consumption and energy production by the local oil and gas industrial operations, however, it is possible to add field gas consumption to the gas and electricity consumption by the industry depicted in Figure VIII. The BTU equivalent of consumption would be about 8 trillion BTU's consumed by the oil and gas operations in the unincorporated areas of the county, including consumption by those off-shore platforms which are linked to onshore processing facilities in the unincorporated area. Total production (oil and gas actually sold) from these same facilities, amounted to about 14.2 million barrels of oil and 10.2 billion cubic feet of gas, with a combined BTU equivalent of 83.3 trillion BTU's. In short, about eight trillion BTU's worth of energy is consumed in the county produce 83.3 trillion BTU's worth of oil and gas. The BTU value of oil and gas production from county operations is further reduced by the unknown amount of energy required to transport and process the crude oil at facilities outside the county.

The largest energy consuming industrial group in the county is the stone and mineral industry. This group includes the manufacturing of concrete, but most of the energy consumption can be attributed to the diatomaceous earth mining industry. Electricity is used primarily for handling and crushing operations. Drying and additional processing require natural gas and/or fuel oils. Natural gas provides most of the thermal energy, but the proportion of gas and fuel oil use varies from year to year. The gas consumption shown in Figure VIII for the stone and mineral industry represents an approximation of the combined consumption of gas and fuel oils.

The food processing industry is the third largest industrial energy consumption group. Most of the energy consumption in this industrial sub-sector is accounted for by the Union Sugar facility in Betteravia. Since production (and therefore energy consumption) is closely tied to the highly volatile sugar market, consumption can vary dramatically from year to year. As with the diatomaceous earth industry, natural gas is often supplemented with fuel oils. The electricity consumption shown in Figure VIII for this industry includes the electricity generated on-site at the sugar manufacturing facility.

The remaining 10% of industrial energy consumption is accounted for by a variety of industries. Major electrical energy consuming operations in the "other" category include the manufacturing of primary metals, electronic equipment and instruments; "other" gas is primarily used for space heating and some industrial processes in a mixture of smaller industries.

<u>Agricultural Sector</u>: Figure IX illustrates the relative importance of gas and electricity for three types of agricultural operations and suggests the end uses of this energy. Electricity is clearly important to the agricultural sector since it is electrical energy which operates most of the pumps used for irrigation. Electricity is also consumed by the wind producing machines used to protect fruits from winter frost.

Most of the natural gas used in the agricultural sector is consumed by the greenhouse industry. Smaller amounts of gas are used to heat other agricultural buildings, to operate gas engines for irrigation, and crop drying.

Although agricultural energy consumption constitutes a small portion (5%) of total county consumption, agriculture does play a very important role in the county in terms of employment, revenues, and land use.

<u>End Use Summary</u>: Perhaps the most useful way to summarize the rather detailed disaggregation of energy consumption patterns in each sector is to combine the energy uses of all sectors into the most common end uses. Figure X shows the relative importance of eight major end uses of energy in the county.

FIGURE IX
AGRICULTURAL ENERGY CONSUMPTION
(BILLION BTUs)

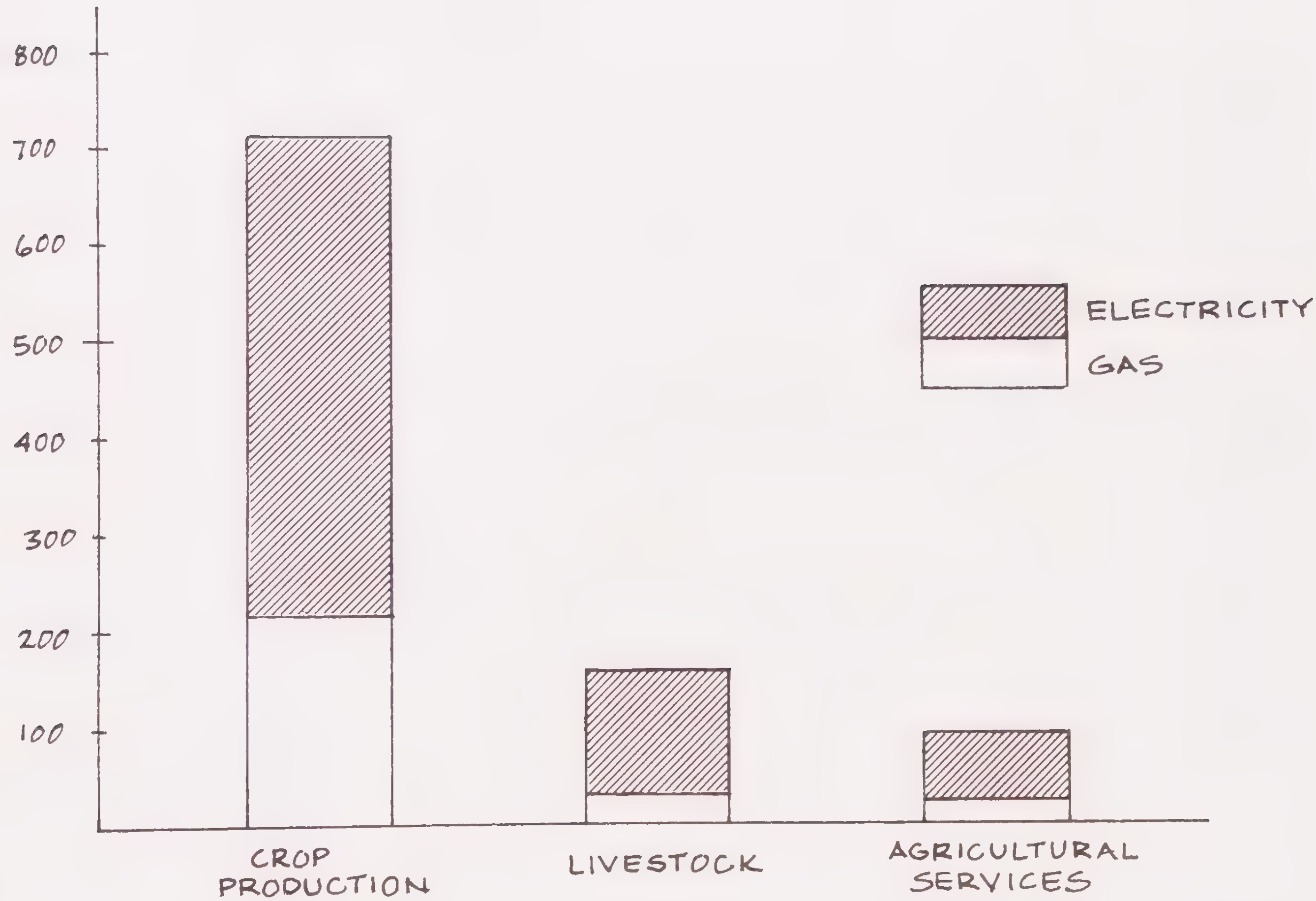
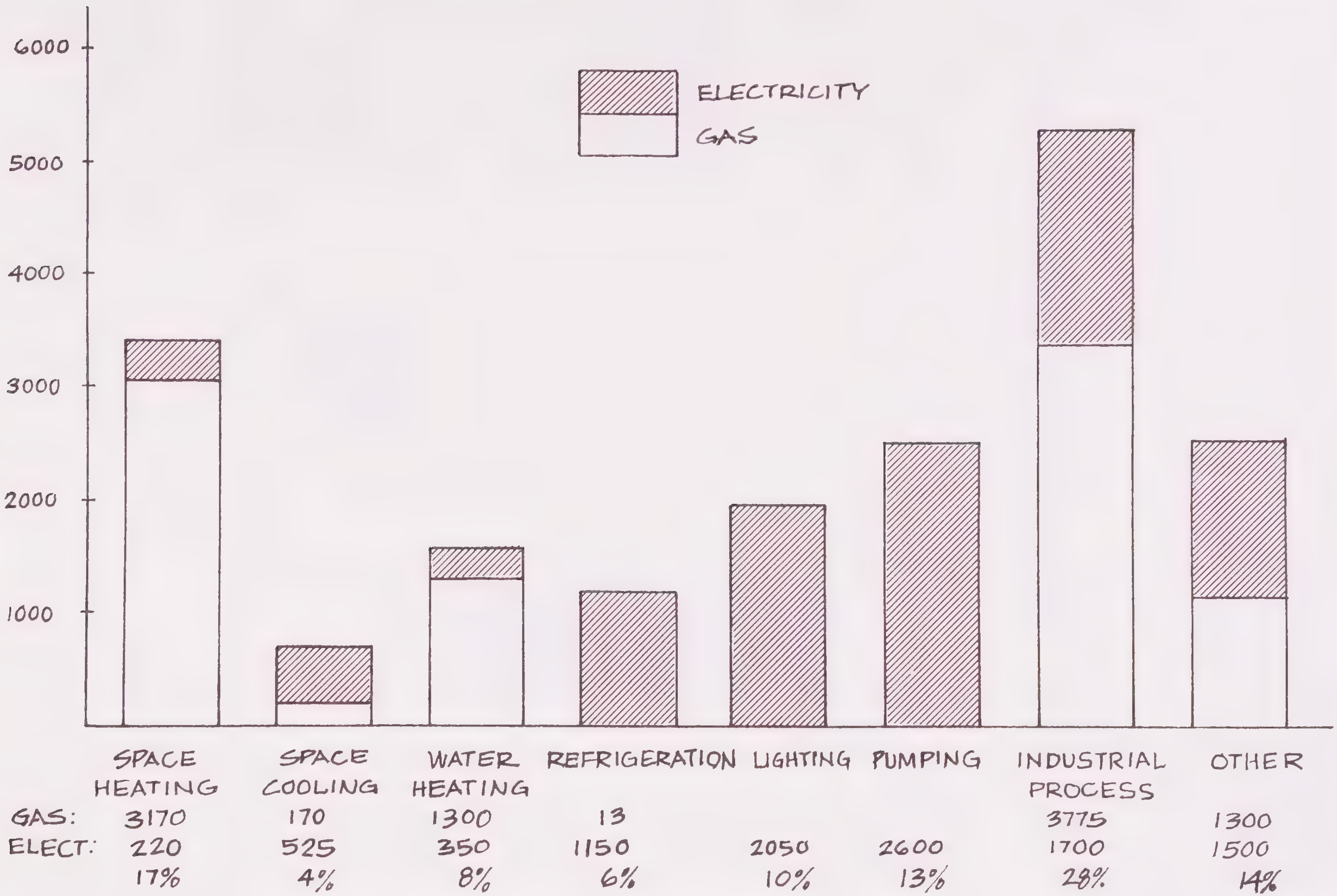


FIGURE X
END USES OF GAS & ELECTRICITY
(BILLION BTUS)



SOURCE: TABLE XII, APPENDIX A

Space conditioning (heating and cooling), water heating, refrigeration, and lighting are all dominated by energy consumption in the residential and commercial sectors. The major exception is the use of gas for heating greenhouses, which accounts for less than 10% of space heating consumption. These five end uses constitute approximately 45% of total county energy consumption.

Pumping is almost exclusively dependent on electricity. Agricultural and industrial uses account for most of the pumping energy consumption. Residential, commercial and industrial use of water frequently depends on the pumping equipment of the water districts, but the energy use for these purposes is comparatively small.

The "industrial process" end use is a general category and includes a number of more specific uses. A significant portion of industrial gas use is for the purpose of heating water to various temperatures. The electricity portion of industrial process consumption includes an unknown mixture of lighting, motor operation, and the operation or more sophisticated electronic equipment.

The "other" category in Figure X includes small amounts of energy for known end uses such as cooking, but most of the gas and electricity uses in this category are unknown.

The uses of energy in the community constitute an intricate web of inter-relationships, penetrating the daily activities of all but a few. Natural gas and electricity perform very useful tasks and have become an integral part of modern life. It is precisely because of the importance of gas and electricity that it is necessary to examine yet another dimension of energy consumption - the price of energy.

THE PRICE OF ENERGY

Until the 1970's, the price of energy was of little concern. Natural gas and the primary energy sources needed to produce electricity were cheap, reflecting the relative abundance of conventional energy sources and a series of legislative and regulatory decisions to subsidize many aspects of the energy supply network.

Although the price increases of the 1970's are frequently attributed to the OPEC price hikes for crude oil, a number of other factors have

played at least as great a role in the escalating costs of energy. In general, the 1970's have been accompanied by the realization that the most accessible, and therefore the cheapest, oil and gas deposits have been or are being depleted. Technological and engineering advances in power plant efficiencies, a significant factor in the decreasing costs of electrical power generation historically, have been more difficult to achieve. The costs of constructing new power plants have risen rapidly in the last decade due to increased labor costs, regulatory delays, and the high costs of capital to finance the plants. The value of continuing to subsidize conventional energy resource development has been questioned and some subsidies have been eliminated. Many of the government price controls on natural gas and oil production and sales, a benefit to the consumer but a disincentive to producers, are currently being phased out. All of these factors have contributed to the sharp rise in the cost of energy, as shown in Figure XI.

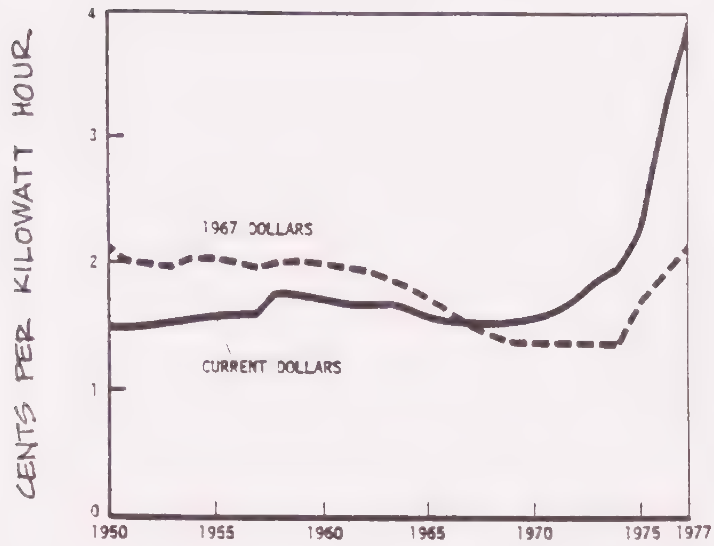
The impact of rising energy costs varies according to the type of energy, socioeconomic group and service class. Although low income groups generally suffer the most, recent federal programs such as the Emergency Energy Assistance Program provide some help to low income families.

All residential customers, regardless of income, have received some relief from rising utility costs from the institution of "lifeline" rates in 1977. In an effort to reduce the impact of higher utility bills on California residents, the legislature required the utilities, through the CPUC, to distinguish between basic gas and electrical residential needs and consumption which goes beyond those basic needs. The lifeline rates are designed to provide essential gas and electricity needs to residents at relatively cheap rates and encourage consumers to reduce excessive consumption by charging higher rates for consumption beyond the lifeline allocation.

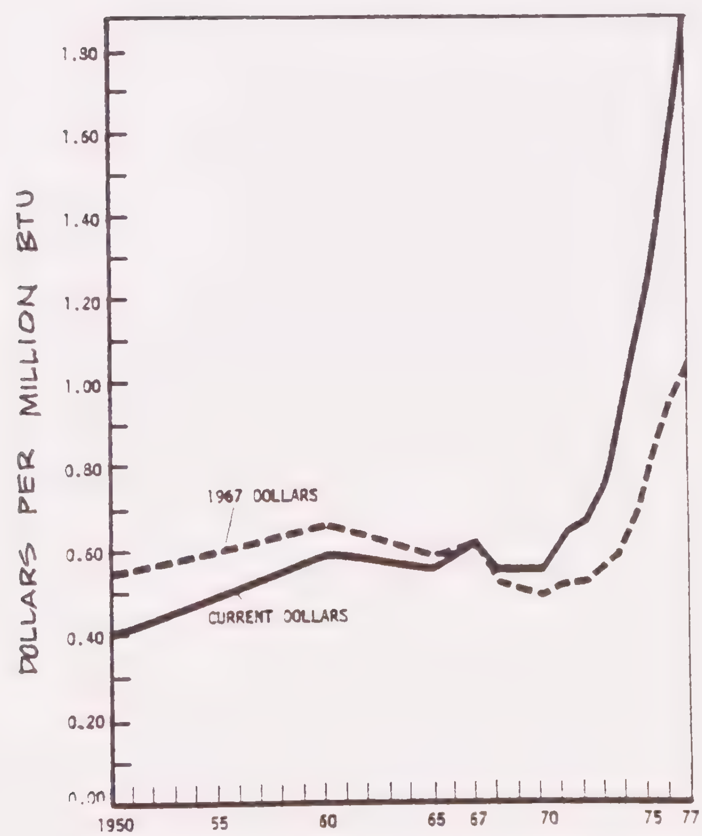
The monthly lifeline allocation for each residential customer depends on the number and type of appliances, the time of year, and the climate zone. Households with electric heating appliances are given a larger electric lifeline allocation than those with gas appliances. Gas and electric lifeline allocations are greater in the winter heating season than during summer months. Since the North County is in a slightly

FIGURE XI
ENERGY PRICE TRENDS
IN CALIFORNIA

ELECTRICITY



NATURAL GAS



SOURCE: CALIF. ENERGY COMM.

colder climate, residents receive a larger lifeline allocation in the winter months. Lifèline allocations for single family homes and most multi-family homes are as follows:

- each household receives 240 kWh for basic electric needs;
- homes with gas water heaters, gas ranges, and gas space heaters receive 26 therms each month plus 55 therms (South Coast) or 80 therms (North County) for each month during the winter heating season;
- all electric dwelling units receive (in addition to the 240 kWh basic allocation) 250 kWh/month for electric hot water heating and either 550 (South County) or 800 (North County) during the winter heating months.

The lifeline rate for residential natural gas is (as of September, 1979) 20.7 cents per therm. Consumption beyond the lifeline allocation costs 25.2 ¢/therm for the next 100 therms, and 30.6 ¢/therm for additional consumption. For homes with appliances not considered essential (swimming pools, dishwashers, washing machines), the cost per therm will be considerably higher than for homes with only space heating, domestic hot water and cooking appliances. The <u>average</u> cost (lifeline and non-lifeline) for gas is about 22-24¢/therm. This does not include the monthly service charge, and can change rather frequently.

Rates for local electricity residential consumption are based not only on similar CPUC lifeline rate considerations, but depend on the utility providing the electricity. Although PG&E and SCE residential customers are given similar allocations, the PG&E rates are lower. The current lifeline rate is 2.6¢/kWh for PG&E customer, and 3.9¢/kWh for SCE. The non-lifeline rate for PG&E customers is 3.8¢/kWh and 4.7¢/kWh for SCE.

The existence of lifeline rates for residential consumers has helped to slow down the rising cost of energy to households. Yet <u>someone</u> must pay for the rapidly rising costs of producing and distributing gas and electricity. The effect of lifeline rates has been to shift a portion of the cost of energy to non-residential customers. Presumably commercial and industrial operators pass on this cost by adjusting their prices for goods and services. As CPUC commissioners William Sumons and Vernon Sturgeon described it in their dissenting opinions on the lifeline decision: "...there is no such thing as a free lunch. The secondary and necessary effect will generally be an increase in prices of other

goods and services. The cost of this subsidy will be the indirect kind that is hidden in every can of orange juice and every sack of potatoes, and consumers never known what's hitting them."

By 1978, approximately 75 million dollars were spent on electricity and gas by Santa Barbara County (unincorporated areas) residential and non-residential customers. The final destiny of this rather large sum of money is rather difficult to determine. In general, the utility retains a portion of this money for their operational expenses and profits, while another large portion goes to the suppliers of energy to SCG, SCE, and PG&E. As noted previously, the suppliers include those local natural gas producers which sell natural gas to SCG and a small portion of crude oil produced locally, refined in California refineries and sold to the electric utilities. A significant portion of the 75 million dollars spent by local customers on gas and electricity, however, ends up leaving the county to pay energy suppliers in California, western United States, and foreign countries.

<u>Future Prices of Energy</u>: The amount of money spent on energy has not only risen sharply in the 1970's, but is expected to rise for some time into the future. Although the projected rate of price escalation is different for electricity and gas, and escalation rates will vary from utility to utility, it is generally agreed that the price of gas and electricity will continue to rise faster than inflation for the next two decades.

One major reason for the expected continued increases in the price of energy is that new natural gas and electricity supply options are all very expensive. The costs of future supplies and natural gas and electricity, known as marginal costs, are expected to be 1½ to 3 times more expensive than current prices. Since these new supplies will come "on-line" at different times, and because new supplies will be mixed with older, less costly supplies, the impacts on the consumer will be delayed and distributed over time.

According to the recent (preliminary) forecasts of the California Energy Commission, the average annual price of electricity purchased from PG&E and SCE is expected to escalate at the rate of about 1% (above inflation) over the next twenty years.

The escalation rates for PG&E and SCE represent the expected twenty year average price increase above inflation and do not distinguish between the cost differences for various classes of customers or fluctuations within the twenty year period. It should be emphasized that these forecasts are preliminary baseline forecasts. They are based on the cost estimates and planned supply mix of the utilities as submitted more than a year ago by the utilities to the CEC. Adjustments to the escalation rates to account for developments in the last year, such as the huge increases in the cost of crude oil and continued increases in the capital costs of power plant construction, will probably result in higher escalation rate forecasts for electricity.

The CEC forecast for natural gas escalation rates is not only higher than for electricity, but is distinguished by significant fluctuations in price over the next twenty years and significant differences in price for different classes of customers. Figure XII shows the preliminary baseline CEC forecast for residential, commercial, and industrial sectors supplied by Southern California Gas Company.

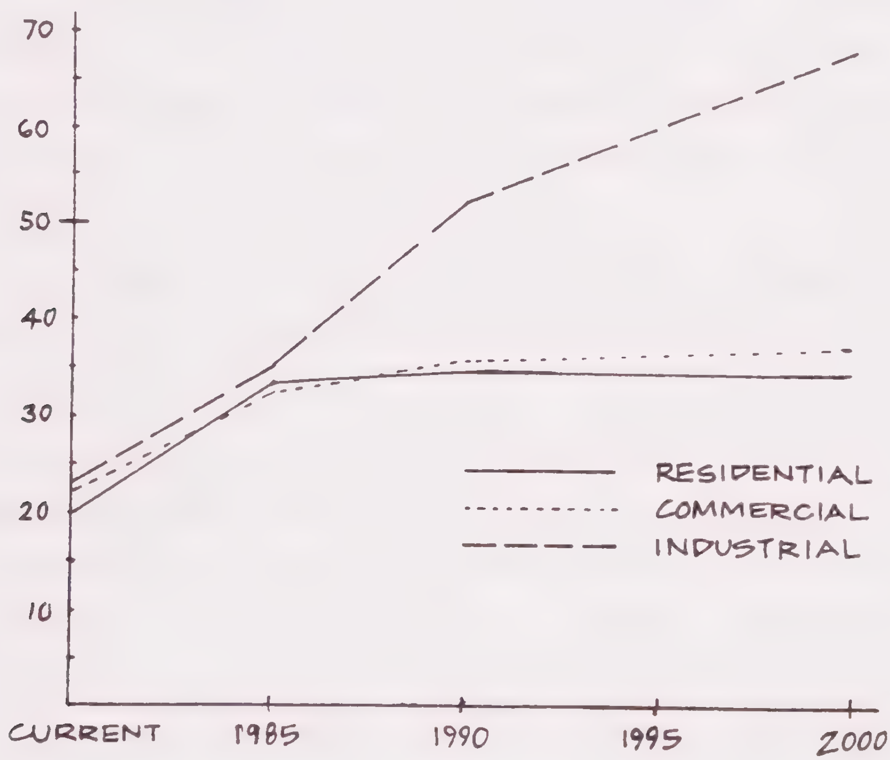


FIGURE XII
PROJECTED NATURAL GAS PRICES
(CENTS/THERM)

As shown in Figure XII, the price of gas for all sectors is expected to rise sharply until the mid 1980's. Residential rates are projected to rise at the rate of about 9% per year (above inflation) during this period, slightly faster than rates for nonresidential sectors. The major reason for this sharp increase is the deregulation of natural gas prices, a federal policy designed to permit the price of gas to rise to levels roughly comparable to world oil prices.

Beyond the mid-1980's, the rate of escalation for natural gas is likely to be characterized by an increasing disparity in the costs to residential and industrial customers. Residential rates are projected to level off while industrial rates experience a continued sharp increase.

While the current differences in the price of gas to residential and non-residential customers can be attributed to lifeline rates for residential consumers, the basis for projecting the growing disparity shown in Figure XII is found in certain provisions of the 1978 National Gas Policy Act which influence the distribution of the higher costs of new supplies to different classes of customers. In effect, after the mid-1980's, large industrial customers can expect to pay the marginal costs of the new, more expensive gas supplies, while residential customers will be paying an average price of old and new supplies. Gas prices will continue to escalate for all customers, but industrial consumers will be paying a much higher price than residential consumers by the 1990's.

The expected impacts of the National Gas Policy Act on natural gas prices raise a number of issues. By asking industrial users to pay most of the marginal costs of new gas supplies, the federal government is able to reduce the impacts of higher prices on residential consumers. As with lifeline rates, the "subsidy" to residential customers will require some industrial manufacturers to pass on their higher costs by raising the price of manufactured goods. Industries which are not able to do so will face difficult times. The combined effect of increased inflation resulting from industry passing on the increased costs and the threat of industrial cutbacks by those industries not able to do so may prove to be an untenable position. The difficult decisions concerning who will pay for the cost of new conventional energy supplies are likely to be the source of continuing political debate. Any legislative decisions to alter the provisions of the National Gas Policy Act are likely to result

in a greater increase for residential customers for the post mid-1980's period.

Several important conclusions can be drawn from the discussion of energy prices:

- the recent rise of conventional energy costs is expected to continue through the end of the century;

- the rate of escalation will differ from utility to utility;

- under current regulatory provisions, the rate of escalation is almost certain to be greater in the next five years than in previous years, and is likely to return to a slower rate of increase in the 1990's;

- the projected lower rates of escalation for the 1990's are less certain than the higher rates projected for the near term;

- under current regulatory provisions, the impacts of increased energy costs will not be evenly distributed;

- the price of future energy supplies will be heavily influenced by political and regulatory decisions;

- the <u>price</u> of energy does not necessarily reflect the <u>cost</u> of conventional energy supplies in terms of the impacts of future facilities and future price disparities will have on the physical and social environments.

The implications for energy consumers - and energy consumption - in Santa Barbara are significant. The decisions shaping the future costs of conventional energy are largely beyond the influence of individual consumers or the county government. The <u>impacts</u> of the decisions by the utilities and regulatory agencies will be felt directly and indirectly in virtually all aspects of community activities.

For purposes of the Energy Conservation Element, the most important implication of the expected continued rise in the price of energy concerns the potential for energy conservation and the use of renewable resources. As discussed in the remainder of this study, the price of energy will be a central issue in defining the opportunities for the promotion of energy conservation and the use of renewable resource technologies.

PART II

ENERGY CONSERVATION AND RENEWABLE RESOURCE POTENTIALS

The increasing costs of natural gas and electrical supplies have been accompanied by an increased interest in reducing the consumption of these resources. Even if it can be assumed that adequate supplies of conventional energy sources will be available, there are good reasons to reduce the dependence on finite fossil fuel resources. Reducing the use of conventional resources can reduce the costs of conventional energy supplies, delay the need for new supplies, and prolong the availability of depletable resources.

A reduction in the use of natural gas and conventional electricity supplies can be accomplished in three general ways:

- by reducing wasteful energy consumption practices and habits;
- by converting the wastes associated with traditional practices into supplemental useful energy supplies; and
- by supplementing or replacing natural gas and electricity with alternative forms of energy.

The discussion of Part II will be organized along these three general approaches. Section I identifies the origins of many wasteful practices and evaluates the options available to reduce the amount of wasted energy. The major end uses of energy consumption identified in Part I of the Energy Element serve as the basis for defining the local opportunities for energy conservations.

Section II centers on the possibility of recovering wastes for the purpose of converting these wastes into useful energy. Three energy conversion applications are discussed: cogeneration (the recovery of wasted steam for the purpose of generating electricity); municipal solid waste recovery and energy conversion; and the conversion of agricultural wastes into useful energy resources.

Section III evaluates the potential for increasing the use of renewable resources. Solar energy, wind energy, the cultivation of crops to be converted to new energy supplies (energy farming), geothermal and hydroelectric are the major renewable resource options discussed in this section.

The opportunities for conservation and renewable resources are so vast that it is necessary to limit the scope of discussion to those opportunities which are most relevant to the County of Santa Barbara in the relatively near term. In all three sections, emphasis is given to an evaluation of the conservation and renewable resource technologies most likely to shape local energy consumption within the next decade. Additional emphasis is given to those options which suggest clear opportunities for local government initiative in promoting the reduction of conventional energy resource usage.

In order to more accurately define the potential for reducing the use of natural gas and electricity, Section IV identifies the projected energy consumption patterns for the years 1985 and 1990. The projected consumption established in this section is based on an explicit set of assumptions about the expected interaction between conservation opportunities and existing state and federal policies to promote these opportunities. An alternative projection, based on the assumption of a strong local government energy program, is offered in Part III of the Energy Conservation Element.

An important dimension to the evaluation of energy conservation and renewable resource opportunities is the issue of cost effectiveness. Subsequent discussions of the local energy opportunities incorporate cost effectiveness considerations whenever possible. Because the meaning of cost effectiveness can vary from situation to situation, the uses and limitations of this term will be explained in the context of more specific applications. A more complete description of cost effectiveness as it applies to energy choices is provided in Part III and Appendix F of Part IV.

SECTION I: ENERGY CONSERVATION - REDUCING WASTES

Most of the buildings in Santa Barbara County were built during an era of inexpensive energy. Since the operating costs of heating buildings and running appliances were low, the primary economic concern was in keeping front end costs - the initial cost of the building or equipment - as low as possible. Buildings were constructed with minimal levels of insulation and weatherstripping, and with little relationship to the climate characteristics of the building site. By today's standard, residential furnaces were often oversized in capacity for the heating requirements of the structure. Electric lights were used in places where windows could have provided much of the lighting load. Appliances were designed with little insulation or other measures which would make them more energy efficient.

Today, with the costs of gas and electricity increasing rapidly, and with future supplies of gas and primary fuels uncertain, there are greater incentives to save energy. Many options exist for improving the energy efficiency of buildings and equipment. Most of these options are not new, nor highly technological. They have been understood for years, but they were not economic options, given the cost of energy resources at the time. Some will cause moderate cost increases for a building or appliance; others are merely different ways of designing or doing things, costing no more than the conventional approach.

ENERGY CONSERVATION OPTIONS

Options for reducing local energy use will be discussed in terms of the following uses of energy:

- space heating and cooling
- water heating
- lighting systems
- appliances
- industrial processes
- pumping
- transportation/land use

Space Heating and Cooling: The efficiency with which a structure can be heated and cooled depends on a number of factors, including:

- the type of energy used
- the orientation and construction of the building
- the type of heating and cooling equipment used
- the habits of the building's occupants

Natural gas and electrical energy provide almost all of the space heating in Santa Barbara County; a small fraction is provided by propane gas. While about 92% of single family dwellings are heated by gas, electricity is used to heat nearly 30% of all multi-family dwellings (Appendix A, Table IV). The amount of energy used for air conditioning is relatively small in the residential sector, but in the commercial sector, cooling is the third largest energy end use. Most of the energy conservation options to be discussed are primarily directed at reducing heating loads. In general, these same energy conservation measures will reduce cooling loads as well.

Electrical heating appliances are usually very efficient at the point of use. However, the considerable amount of primary energy required to generate and distribute electricity results in a very inefficient use of this energy form. About 60% of the primary energy required by a fossil fuel power plant to generate electricity is lost in the conversion process. Additional energy losses occur in the transmission of electricity to the buildings where it is used. Natural gas appliances are not as efficient at the point of use, but since little energy is lost in transporting the gas from its source to the building, natural gas has a much higher overall efficiency. On the whole, gas space heating is 60-75% efficient, compared to electric space heating efficiencies of 30-40%.

The State Energy Conservation Building Codes, known as Title 24, contain provisions discouraging the use of electric space heating in new buildings However, these provisions have proven difficult to interpret and administer. Particularly in the case of multi-family residences, building practices often make the installation of electric space heating more attractive than gas. Because of these problems, the State Energy Commission is considering revision of the Title 24 standards.

Whether equipped with gas or electricity, there are many opportunities for increasing the efficiency of space heating and cooling. The type of unit built, its size and volume, all contribute to the resulting energy requirements of that structure. Generally, buildings which share common walls, such as multi-family and some commercial units, use significantly less energy than detached structures. Common walls reduce the outside surface-to-volume ratio of each unit, so there is less surface area through which heat can pass.

The resistance of a wall, ceiling or floor to heat flow - known as the 'R-value'-can be increased by adding insulation materials. The greater the R-value of an insulating material, the greater resistance it has to heat flow. A well insulated house will have a minimum of R-11 insulation in the walls, and R-19 in the ceiling.

According to local utility estimates, only about 12% of the residential building stock currently has R-19 ceiling insulation. Another 57% are under-insulated, meaning they have ceiling insulation rated at less than R-19 (typically R-7 or R-11), and 31% have no ceiling insulation (see Appendix B, Table I). Many of those dwelling units which already have R-19 ceiling insulation are "Gold Medallion," all-electric residences, particularly apartments. These units were typically insulated to a much higher R-value than gas heated units to keep the operating costs of electric heaters competitive with gas.

Adding R-19 ceiling insulation to an existing home or apartment (known as retrofitting) can reduce the energy required for space heating by the following percentages:

	Estimated % of energy saved
Retrofitting an uninsulated residence	20-33%
Retrofitting an underinsulated residence	3-15%

A major source of heat loss in a building is through the windows and exterior doors. Adequate weatherstripping for doors and windows can help to reduce air leaks, and so reduce the heating requirements of the structure by about 8%. Additional reductions in consumption can be achieved with the use of thermopane windows. In existing homes, thermopane windows are generally very expensive to install, however, their use in new construction can prove to be cost effective.

Buildings located in windy areas are particularly vulnerable to considerable heat losses in the winter months. Chilly winter winds in areas such as Lompoc, can add to the heating load of a structure by increasing the amount of air infiltration from the outside, and by drawing heat off of the building. An effective energy conservation measure for buildings in windy areas is the planting of trees and shrubs for wind breaks. The chosen vegetation for a wind break should have dense growth, and be as tall or taller than the structure it is to protect.

In addition to the energy conservation measures already discussed which require physical changes in the structure or its site, substantial energy savings can be made if building occupants are willing to make some behavior changes. Some of the more significant changes include:

- Setting back the thermostat at night can reduce furnace energy use by about 10% (clock thermostats can achieve the same savings automatically at slightly less dollar savings)

- Shutting off the pilot light on a residential furnace during the warm seasons of the year can reduce annual furnace energy use by 5%

- Lowering the winter thermostat temperature and raising the summer setting reduces the rate at which heat flows in and out of the structure

The amount of electricity or gas used to heat and cool buildings can be reduced in many ways. Some conservation measures require changes to the structure itself, while others are the result of changes in daily habits. Figure I illustrates the relative importance of the major options for reducing space heating energy use. The percentages shown represent the energy savings which would result in many single family homes in the county which were built with little regard for energy conservation.

In order to prevent the continued construction of buildings requiring large amounts of gas or electricity for space heating, the state has adopted energy conservation building regulations. California's Title 24 standards set required levels of thermal performance for new residential and non-residential buildings. The standards include insulation requirements for ceilings, walls, and floors based on local heating needs and weatherstripping requirements for all exterior doors and windows.

FIGURE I
SPACE HEATING ENERGY SAVING POTENTIAL

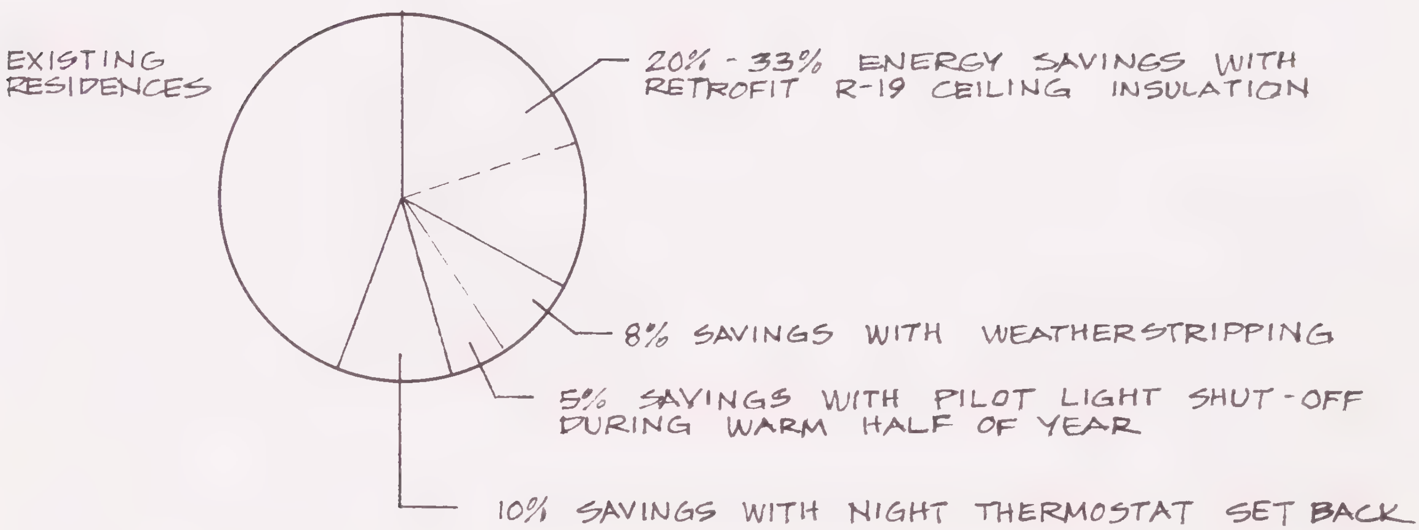
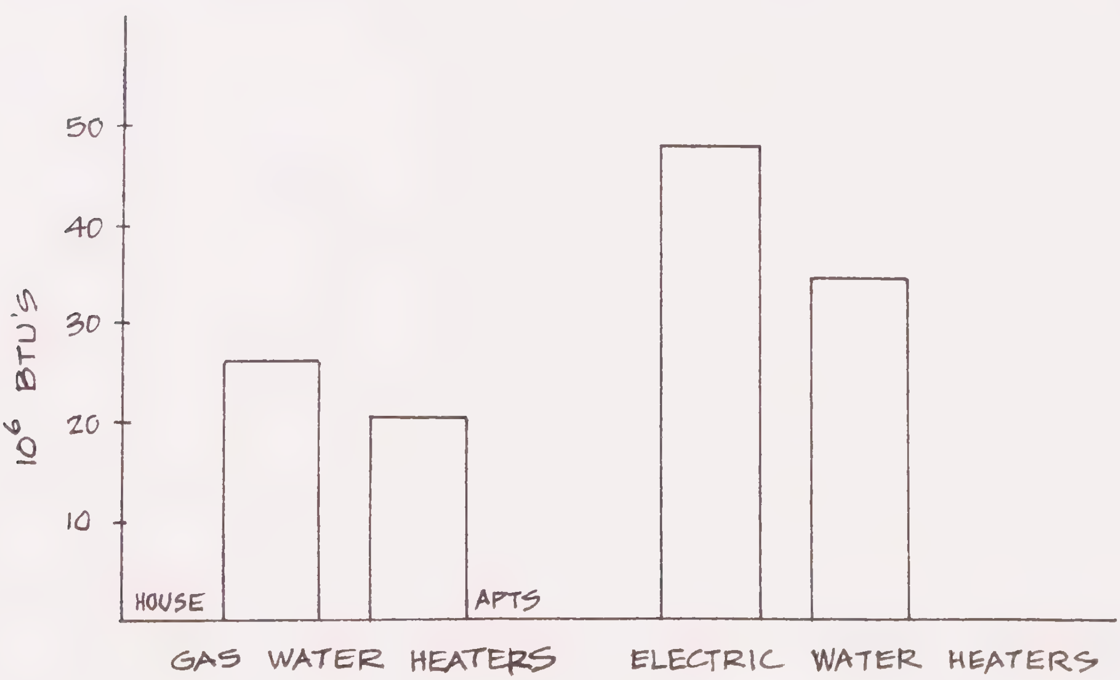


FIGURE II
ENERGY REQUIREMENTS OF GAS & ELECTRIC WATER HEATERS



The Title 24 standards can be viewed as the minimum required energy conservation standards for new structures. Local governments have the authority to go beyond these standards with stricter mandates, if such regulations are in the public interest. Some local governments such as Davis and Indio have chosen to adopt their own building codes which meet or exceed the state standards for thermal efficiency. State and federal governments are also providing incentives for energy conservation. People who build-in or retrofit energy conservation hardware on their homes may be eligible for state or federal tax credits. The state tax credit is available only for those investments made in conjunction with a solar system. The federal program applies to most energy conservation investments, allowing a tax credit of up to 15% of the cost of the energy conservation investment.

Water Heating: The major sources of inefficient energy use for water heating include:

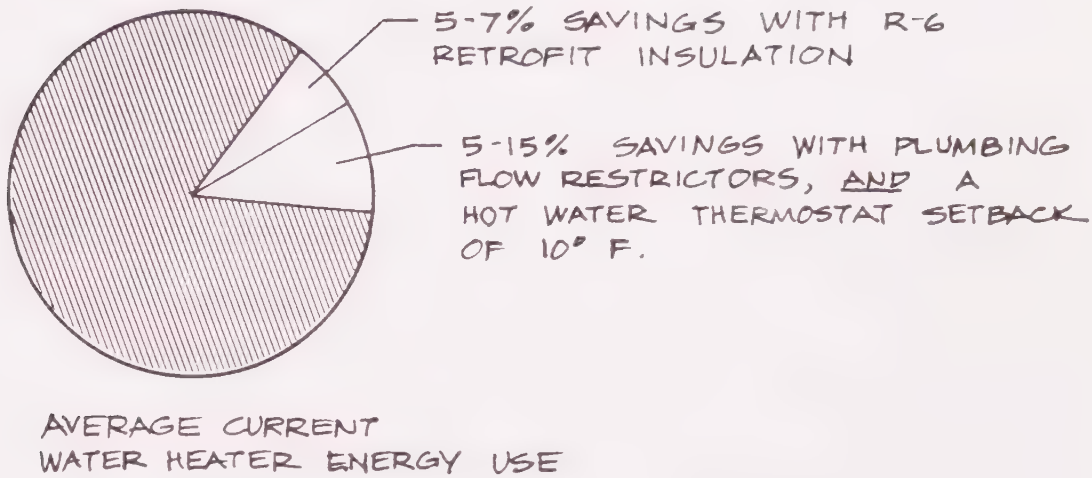
- use of electric resistance water heaters
- little or no insulation around the water heater tank
- maintaining water at a higher temperature than actually required
- wasteful use of hot water

As with space heating, electricity is much less efficient than gas for heating water. Figure II shows the equivalent BTU energy consumption of both gas and electric water heating.

The thermal performance of a water heater tank is highly inefficient without insulation. In Santa Barbara County, a tank insulation jacket (a layer of R-6 insulation installed around the tank's exterior), can reduce the annual energy requirements of a typical gas water heater by 20 therms, and an electric water heater by 360 kWh - or about 5-7% in each case. Reducing the thermostat setting on a typical heater by 10°F, and adding shower and faucet flow restrictors can save an additional 5-15% of water heater energy consumption. Flow restrictors save energy by reducing the amount of hot water used, as well as reducing the amount of energy required for water pumping, since less water is being used. Figure III indicates the energy savings potential of the various conservation options discussed for water heating.

FIGURE III

MAJOR OPTIONS FOR REDUCING WATER HEATING ENERGY



The Title 24 standards for new residential and non-residential buildings set a number of requirements for water heating as well. The use of electric resistance water heating is discouraged. Performance standards are set for all plumbing fixtures to limit water flow. Insulation of water pipes which traverse unheated spaces is required.

Lighting: In Santa Barbara County, the largest single commercial use of energy is for lighting. In the residential sector lighting is the fourth largest end use.

In many buildings, lighting systems have been used which uniformly light the interior space. Often the activities occurring do not require the same level of lighting throughout the building; therefore a lot of energy is being wasted by unnecessary light fixtures. Even more energy is wasted, because lighting adds heat to the building interior, requiring air conditioning equipment to operate longer.

In existing buildings, these inefficient lighting systems can be replaced with more efficient task-oriented lighting which selectively illuminates activity areas. Other options for reducing the energy requirements of lighting include: disconnecting unnecessary light fixtures, known as delamping; and replacing incandescent lights with more energy efficient

fluorescent or sodium-vapor lighting, known as relamping. Lighting energy savings of 25-50% are possible by employing these conservation options.

The cost savings from modifying existing lighting systems can be substantial. Santa Barbara County government's delamping program has saved $25,000 in energy and maintenance costs in a little less than two years.

The Title 24 building codes include illumination standards for new non-residential building interiors. The standards are based upon the type of activities which will be carried out within a structure.

Appliances: Like buildings, appliances were designed to minimize the manufacturing costs, and to be fairly durable. Now that energy costs have made operation of appliances more expensive, there is sufficient reason to design and utilize equipment which is much more energy efficient

There are a number of voluntary options for reducing energy use in existing appliances; most of these are aimed at reducing the duration and frequency of appliance use. The more significant options for space and water heating appliances have already been mentioned (i.e., setting back thermostats). The utilities also recommend the following measures to residential customers:

- Refrigerators and Freezers: Check the seal around the door edges and make sure it is in good condition. Keep the condenser clean so that it can operate most efficiently. Keep manual units as frost-free as possible.

- Dishwashers: Skip the drying cycle and prop the door open to air dry dishes. Wash only full loads. Use short-wash cycles as much as possible.

- Clothes Washers and Dryers: Wash full loads only. Use cold water whenever possible. Use a clothesline instead of the dryer.

- Furnaces and Heaters: Maintain heater outlets and air intakes in a clean condition; change filters regularly.

- Cooking appliances: Avoid pre-heating ovens. Do not use small pans on large cooking elements. Cover pots and pans.

To curtail the manufacturing of energy inefficient appliances, California has adopted energy efficiency standards for new appliances (known as

Title 20), which have been found to be significant energy consuming end uses. At present, standards have been adopted for the following appliances:

- Electric refrigerators, freezers and combined units
- Gas space heaters
- Water heaters
- Plumbing fittings
- Gas clothes dryers
- Gas cooking appliances
- Air conditioners

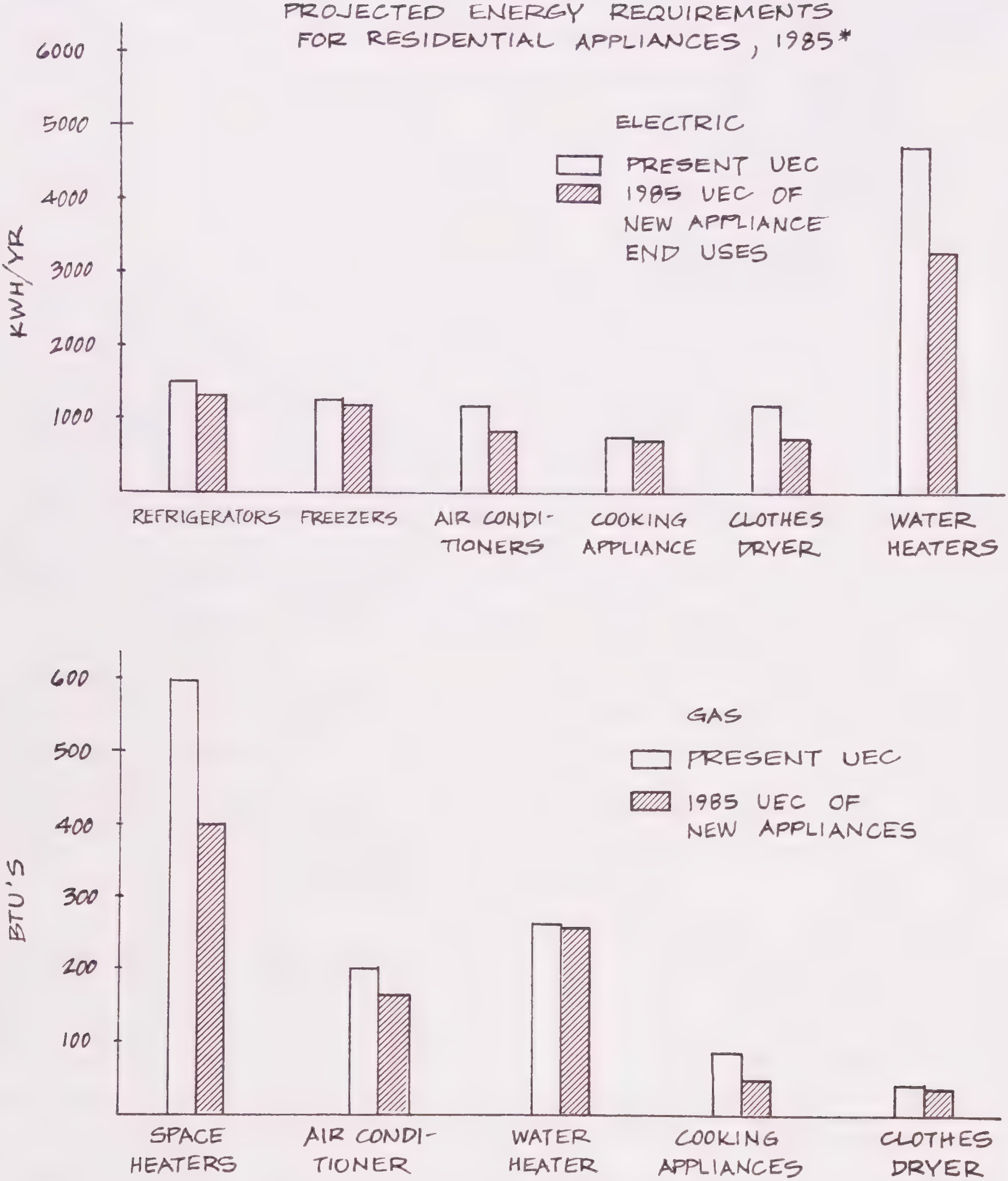
These standards apply to new appliances retailed in California, regardless of where they are manufactured. Typically, the standard for each appliance is stated as a required measure of operation efficiency. Most of the standards have two or more implementing phases, so that manufacturers will have sufficient time to make the necessary design and production changes, and to clear present stock inventories. Following each succeeding deadline, an appliance cannot be sold in California unless it has been tested and certified as complying with the standards.

Figure IV shows the estimated local energy savings per appliance which will result from full implementation of the appliance efficiency standards. Incorporated into the savings estimates for gas space heating and cooling appliances are the conservation effects of the Title 24 building standards as well. Figure IV is a summary of the conservation effects of both Title 20 and Title 24 standards upon the energy requirements for single-family residential end uses within Santa Barbara County.

Industrial Processes: There is a large potential for improving the energy efficiency of industrial operations. As with non-residential buildings, however, the diversity among industries means that no single conservation measure is broadly applicable throughout the sector. Conservation potentials must be identified on a plant-by-plant basis. Overall estimates of the potential for conservation to reduce U.S. industrial energy use range anywhere from 10-30%. The following paragraphs summarize some of the general options for achieving industrial energy conservation.

Monitoring of industrial processes can lead to improvements in energy efficiency. Changes in the timing of processing operations, or in the monitoring practices themselves can result in substantial energy savings.

FIGURE IV
PROJECTED ENERGY REQUIREMENTS
FOR RESIDENTIAL APPLIANCES, 1985*



SOURCE: APPENDIX B

* THESE UEC'S ARE FOR SFD. APARTMENT APPLIANCES WILL UNDERGO ROUGHLY THE SAME UEC REDUCTIONS

** FIGURES FOR GAS SPACE HEATING, COOKING, & ELEC AIR CONDITIONING, INCLUDE THE EFFECTS OF THE TITLE 24 STANDARDS.

Maintaining optimal boiler efficiencies by monitoring flue gases and adjusting boiler equipment accordingly, is one example. The use of automatic timing devices on equipment which is used only intermittantly is another option.

Modifying industrial equipment to improve its energy efficiency generally requires substantial investment, but the energy and dollar savings can be large. Near Santa Maria, the Conoco Co. insulated some heavy crude oil storage tanks at it's Cat Canyon field operations. The crude must be kept hot so that it does not solidify; insulating the tanks to curtail heat losses has significantly reduced the heating energy Conoco requires. Other equipment modifications which can lead to energy savings include:

- Installing insulating on pipes and equipment through which steam or hot water flows;

- Installing equipment to recover and use waste heat given off by process hot water, steam, and other heat sources (cogeneration is discussed further in Section II.)

New processes coming into use for a number of industries will significantly decrease the energy requirements of new plants and equipment. Often, in the design of new plants and processes, there are more capital or labor-intensive alternatives available which will save energy over the more economic options. With today's increasing energy prices, these energy conserving alternatives are becoming economic as the energy cost savings potential begins to equal the added capital costs.

The state has recently adopted legislation requiring the electric utilities to set up load management programs designed to reduce peak loads of electricity demand. The purpose of these programs is to lessen the need for new electrical generating capacity, and so to reduce primary fuel consumption.

As part of this program, the utilities are providing energy management surveys to their larger industrial (and commercial) customers. Like residential energy audit only much more complex, the energy management survey includes analysis of plant processes, lighting, and the building envelope to identify ways of improving energy efficiency. PG&E has estimated that these surveys will lead to an average plant energy savings of 7,000-9,300 kWh per year. PG&E expects that the combined effect of

these surveys, plus industrial energy conservation seminars and agricultural pump 'tune-ups' will reduce electrical energy consumption in the county by 10%.

Another legislative act recently adopted by the state, has authorized a feasibility study of energy conservation survey programs to achieve a 20% improvement in non-residential energy efficiency, statewide. The study is now being undertaken.

Pumping: Pumping is the third largest energy consuming end use in Santa Barbara County. Most of this end use is attributable to water for agriculture and industrial oil pumping. Electricity provides most of the pumping power, although natural gas engines are sometimes used for agricultural pumping.

State programs to reduce the peak load electrical energy used for agricultural water pumping have been initiated only recently. A joint feasibility study by the utilities; the Public Utilities Commission (PUC), and the Energy Commission has recommended further study of using time-of-day pricing to promote crop irrigation during off peak, nighttime hours. PG&E and SCG have already instituted these rate structures. Further evaluation is needed, however, of the effect of off-peak irrigation upon the local water supply, and the economic effect upon farming operations. The energy efficiency of all pumping can be improved with adjustments to and maintenance of pumping equipment. Both PG&E and SCG will do pump 'tune-ups' upon the request of their agricultural customers.

Transportation/Land Use Planning: Conventional land use development patterns have tended to be energy inefficient. The cause and effect relationships between land use patterns and energy consumption are not completely understood, but the following development trends appear to be associated with greater energy consumption:

- Suburban residential development located far from employment, commercial, and transit routes require greater dependence on the automobile;

- Leap-frog development to outlying areas makes the provision of transit and other public services more costly and less efficient; and,

- Low density, detached development requires more energy for use in space heating and cooling compared to higher density units with common walls.

The increased energy consumption associated with these development patterns contribute to increased air pollution and other environmental problems. The relationships between energy consumption, land use planning, and air quality have been assessed in several existing county documents: The Conservation Element, and the Air Quality Attainment Plan (AQAP). As part of the AQAP, the County Office of Air Quality Planning has proposed a set of land use policies for various areas of the county. The most significant measures include a balanced growth of commercial, industrial, and residential expansion, and a priority for high density housing with accessibility to non-automobile transportation opportunities and proximity to shopping and work areas. The air quality benefits associated with these measures would be accompanied by reductions in local energy consumption for transportation and residential space heating.

CONSTRAINTS ON ENERGY CONSERVATION

Improving the efficiency of energy use makes increasing economic sense from the standpoint of rising costs and the insecurity of future energy supplies. However, there are many barriers to full implementation of energy conservation options.

Common Perceptions and Lack of Information: Many people are not aware or or do not believe that conservation measures can have a significant effect in reducing future energy requirements. Many believe that energy conservation will mean doing without, changing one's lifestyle. Perhaps most importantly, few people are aware that many energy conservation investments can pay for themselves in relatively brief periods of time through the energy dollars they save.

Another prevalent and strongly entrenched belief is that growth in energy demand and growth in the Gross National (and State) Product are positively related; that reducing energy use means a slowdown in the economy. Recent trends in each of these indicators show that this is not the case. In California, the gross state product has grown almost twice as fast as electricity sales in the state since 1973.

Outreach and education programs and public advertisement are the main tools for distributing energy conservation information, and dispelling some of these constraining perceptions. Utility sponsored advertising for energy conservation is an educational mechanism being used extensively in Santa Barbara County and throughout the state. Energy conservation

campaigns and information clearinghouses, sponsored by community groups or local governments are another approach.

Costs: Many of the more significant energy conservation opportunities cost money. In the county, it is estimated that retrofitting an uninsulated single-family dwelling with R-19 ceiling insulation can cost $700 for a 2,000 sq. ft. house (Appendix B, Table VIII). This kind of cost can be a major disincentive to maximizing energy savings. To encourage energy conservation investments, the federal government offers a 15% income tax credit to help reduce the initial costs. Pending legislation would increase this credit to as much as 50%. Taking into account the expected escalation of energy costs, the $700 cost for attic insulation should be recaptured within 10 years.

Education programs, aimed at informing people about the overall dollar savings which will result from energy conservation investments is one strategy of overcoming the cost barrier. Particularly needed is consumer information which is specific to the county, providing dollar cost and saving estimates for energy conserving measures implemented within the local region.

Yet, even if the cost effectiveness of conservation investments is understood, the first costs of these investments can still be a deterant, particularly for lower income people. Locally, the Community Action Commission, Inc., a private non-profit program, provides grants for weatherization of low-income family residences. In the past 2½ years, the Commission has provided funding for over 700 residential weatherization jobs in the county. The National Energy Act of 1978 has increased funding support for this type of program.

For other people interested in making energy conservation investments, the costs of energy conservation must be paid up-front, or defrayed through financing.

Financing Practices: Large investments in energy conservation equipment may appear unattractive to the consumer. The unavailability of low-interest loans for energy conservation investments is a further disincentive to purchase and install equipment with a higher front end cost, although it will ultimately save dollars in the long run.

With a low-interest (i.e., 8%) loan, the return on an investment in many energy conservation measures would substantially outweigh the added cost of financing. But there are few lending institutions providing such low interest loans for energy conservation to the general public. Most conservation investments must be financed by a standard home improvement or business loan at an interest rate of about 18%. It is only recently that some financial institutions have considered offering lower interest loans specifically for energy conservation investments.

Currently, the state government provides some low interest energy conservation loans, but these are predominantly for low to moderate income households, not for general distribution. The California Public Utilities Commission (CPUC) is expected to require utilities to offer 8% loans for conservation investments, which residential customers could then repay on their monthly utility bill.

Energy Conservation Barriers in the Rental Market: In Santa Barbara County, approximately 18% of the single family and 19% of the multi-family units are rented; this represents about 40% of the county's residential stock.

The structure of the residential rental market presents substantial barriers to energy efficiency improvements. Landlords have little reason to invest in energy conservation measures, because they do not pay the utility bills for their rental units; if they did, the cost would be passed on to the tenant. Tenants have little incentive to invest in energy conservation measures either, even though they must pay the utility bills. The average period of tenancy is so short that a tenant would lose money by making conservation investments. The problem is further exacerbated by the highly speculative character of the rental unit market. Owners of investment properties intend to re-sell their property in a very brief span of time, so they have even less incentive to upgrade their properties than long-term owners of rental properties.

Conceivably, voluntary arrangements could be worked out between the landlord and tenants to invest in energy conservation measures, and agree upon an increased rent payment until the investment is paid back. The

tenants would regain part or all of the increased rent payment in the money saved on utility bills. Such a scheme however, would require extraordinary cooperation and motivation on both parts.

SUMMARY

The local potential for energy conservation is substantial. Unnecessary energy wastes and inefficiencies occur within every category of end use. As has been indicated, a very large proportion of this waste can be eliminated cost effectively, with a resulting net dollar savings in the form of less costly utility bills. Yet, a number of economic and institutional constraints stand in the way of maximizing energy savings.

Traditional building practices and the historically cheap costs of energy have been the two major constraints to the development of energy conserving buildings and equipment. The state mandated building codes and appliance efficiency standards represent major attempts to overcome these constraints.

However, the state's mandated standards will reduce local energy consumption by only a very small amount. The major bulk of residential and commercial energy consumption, for a number of years to come, will be that demanded by today's existing stock of buildings.

Education and incentive strategies such as the ceiling insulation retrofit programs sponsored by utilities, will not be adequate to overcome the constraints upon energy conservation within existing structures. In particular, the costs of retrofitting energy conservation hardware and common misperceptions about energy conservation will keep people from making these energy saving investments.

The existing rental market, in particular, which constitutes a large proportion of the county's housing stock, will continue to be energy inefficient because neither landlords nor tenants have enough incentive to invest in insulation or other conservation measures.

The major local potentials for energy conservation lie in overcoming these constraints upon energy conservation in existing structures.

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SECTION II: CONVERTING WASTES TO ENERGY

A second general approach to energy conservation involves the conversion of wastes into energy. Three applications are discussed in this section as indications of the local potential: cogeneration; municipal solid waste recovery and conversion; and agricultural wastes.

COGENERATION

Cogeneration is a process which makes use of waste heat to drive a turbine which generates electricity. Industry commonly burns natural gas and liquid fuel to produce steam for processing needs, but much of the useful work that the steam could perform is lost in the process. With the addition of a cogeneration unit, the waste heat that would normally be released in a smokestack or vent can be used to generate electricity for the facility itself or be sold to a utility company. Cogeneration can also be used in a process involving only waste heat recovery boilers for steam production, without generation of electricity.

Cogeneration is a known technology which has been used successfully for decades. In Santa Barbara County, the Union Sugar Company has used a cogeneration unit since the facility opened in 1897. With the installation of more modern equipment in the early 1970's, Union Sugar has been able to produce about 90% of the electrical energy it needs. The manufacturing of sugar requires the use of large amounts of steam, making the use of cogeneration very attractive.

Another local industrial process, the injection of steam for improving oil recovery, presents a promising opportunity for the use of cogeneration. The CEC has identified thermal Enhanced Oil Recovery (EOR) operations as a major application. Electricity can be generated by using the steam to turn a turbine before the steam is injected into the oil reservoir. Most of the state's heavy oil reserves are located in Kern County, which is likely to be the site of the first EOR cogeneration unit. One specific proposal is expected to produce 280 MW of electricity. PG&E would own the cogeneration facility and use the surplus electricity for its power supply.

The use of cogeneration in Santa Barbara County heavy oil fields is still very speculative. PG&E has conducted preliminary discussions with a local oil operator concerning the possibility of a cogeneration facility in the Cat Canyon area, south of Santa Maria. The conditions in the Santa Barbara heavy oil fields differ from those in Kern County in several respects, making the possibility of local cogeneration applications more problematic. In comparison to Kern County, steam generation equipment in the Cat Canyon area is smaller and operations tend to be dispersed over a wider area. The attractiveness of a cogeneration facility would be increased by consolidating the steam generation equipment within a particular oil field or among adjacent fields. Since there are at least seven major oil producers in the Cat Canyon heavy oil fields, however, negotiations for a consolidated facility would be difficult.

To a large extent, the prospects for EOR cogeneration facilities in the county will be shaped by future levels of heavy oil production. Increased heavy oil production in Cat Canyon would require a greater use of steam. An increase in the amount of steam for one particular field or several operators would enhance the attractiveness of using the steam to generate electricity as well.

The production of heavy oil in Santa Barbara, as elsewhere, has been restricted by two factors--the low market value of heavy oil and the air quality effects of burning fossil fuels to produce steam for injection. Increased federal interest in expanding domestic oil production prompted President Carter to provide substantial economic incentives to heavy oil producers. The decontrol of heavy oil prices, adopted in August, 1979, is certain to increase the possibility of expanded heavy oil production in the next decade. Unless the air quality impacts of increased production can be resolved, however, heavy oil production levels will continue to be restricted.

The use of cogeneration for enhanced oil recovery operations does not itself create any significant air quality problems, yet the overall prospects for the use of cogeneration will be influenced by future levels of heavy oil production. Under the right technological, economic, and environmental conditions, it is not unreasonable to expect the use of cogeneration in local operations within the next

decade. An estimate of the amount of electricity generated under these conditions is difficult to determine, but the potential for considerable surplus power generation could be expected. Presumably surplus electrical power would be used in the PG&E power grid.

Cogeneration technologies are not necessarily limited to large industrial users of steam. Plans for a cogeneration unit in a steam heating facility at U.C. Davis have been finalized with construction scheduled for early 1980. Other university facilities are also being considered by state and university planners in terms of cogeneration potential. This could result in significant savings in communities such as Santa Barbara, where the university is a major consumer of energy.

All cogeneration applications face some common constraints and opportunities. The constraints are:

- The volume of steam generated (and therefore the electricity potential) must be large enough to justify the expense of a cogeneration unit.
- Capital is not always available to finance the initial investment.
- The requirement of a 1-3 year payback period, a common criteria for private industry investment decisions.
- The return on the investment must be realized through energy savings or the sale of electricity.

Some of these obstacles may be overcome in the near future. The National Energy Act (NEA) provides tax incentives for conservation investments, such as cogeneration units. The CEC has a program which has funded several proposals for cogeneration feasibility studies. Additionally, the CPUC is expected to require California electric utilities to purchase surplus power from cogeneration facilities at marginal rates. The combined effects of tax incentives and favorable utility pricing schemes should help to increase the near term attractiveness of cogeneration. The California Air Resources Board (ARB) has recommended that operators of steam generators be given a delayed compliance schedule for achieving the ambient air quality standards, provided they will be replacing the steam generators subject to the regulations with a cogeneration unit. This delayed compliance schedule is intended to encourage commitments

to cogeneration by eliminating the need to clean up existing steam generators with high emissions resulting from the burning of fossil fuels. As with other conservation approaches, the potential for cogeneration in the county will be shaped by a variety of technological, economic and social considerations.

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MUNICIPAL SOLID WASTE RECOVERY AND ENERGY CONVERSION

The consumption and manufacture of goods, from soft drinks to washing machines, is very energy intensive. Besides the energy consumed to actually utilize a product, a great deal of energy is required to manufacture and dispose of the product. Currently, the terminal point of this energy flow is the local dump. Solid waste recovery and conversion are intended to reduce the size of the consumer goods energy flow and tap the energy contained in refuse.

The basic nature of any municipal solid waste (MSW) resource program is dictated by the contents and amount of waste generated. The composition of MSW determines the types of energy products and materials that can be recovered. The amount of MSW determines the amounts of recoverable materials and energy and the appropriate recovery technologies.

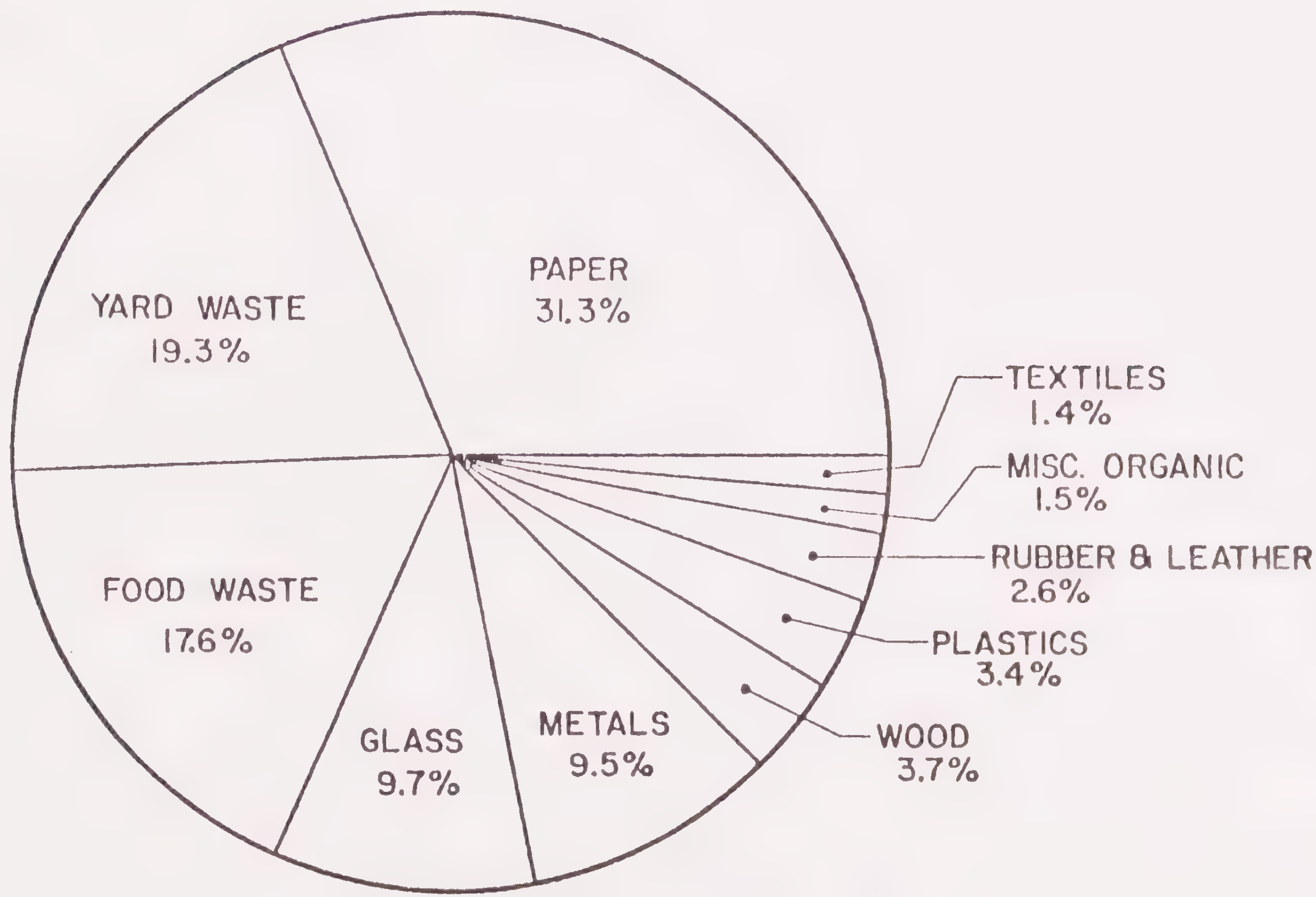
In 1975, the county generated an average of 867 tons/day of MSW. This is expected to rise to about 1108 tons/day by 1990. Over two-thirds of the county's MSW is disposed at county-operated landfills. Most of this waste is landfilled at Tajiguas, located between Goleta and Gaviota. The useful life of Tajiguas has been estimated to extend to the year 2000. The County Department of Public Works is concerned that the actual useful life of the site may be somewhat less, due to unexpectedly rapid growth in waste volume and a possible shortage of cover material.

The composition of the local waste stream is more difficult to estimate. The composition of disposed material varies with every community, but an approximation of the local waste stream can be determined by using national estimates. Figure V illustrates the nature of the materials commonly disposed in a U.S. landfill site.

Reducing the energy wastes associated with traditional disposal processes can be accomplished in two general ways:

- Material recovery: collecting and using recycled materials which consume less energy than virgin materials in the manufacturing process;
- Energy Conversion: converting MSW to fuel, heat, or electricity to replace conventional energy sources.

FIGURE V
COMPOSITION OF SOLID WASTE



SOURCE: OFFICE OF SOLID WASTE MANAGEMENT PROGRAMS, WASH. D.C.

MATERIAL RECOVERY

Recovery of recyclable material from county MSW can both save energy and extend the life of county landfill sites. Recyclable materials--paper, glass, and metals--constitute over half of the county's MSW. Based on U.S. Environmental Protection Agency (EPA) potential resource recovery rates, the county could reduce its waste stream volume by about 20%. A waste stream reduction of this magnitude would extend the life of existing landfills. No estimate of the length of the extension could be made.

Recycling materials such as paper, metals, and glass can save significant quantities of energy. Virgin material must be extracted and refined before being used. Use of secondary materials eliminates the extraction and refining steps, along with the energy consumed by these steps. Use of recycled material in copper and aluminum production reduces energy requirements for these materials by over 90%. Energy reductions of over 70% can be achieved in steel and low grade paper production. If the county attained its resource recovery potential, total energy savings would amount to 212,000 barrels/year of oil by 1990. These energy savings wuld be realized at the point of material production, not in Santa Barbara County, the point of recovery. Such reduction is important to the national goal of reducing total energy consumption, however. Material recovery can be achieved by collecting recyclable material before it goes to the dump or by separating and recycling material prior to final disposal at county facilities.

The Santa Barbara Resource Recovery Program, which collects recyclable material is sponsored by the City and County of Santa Barbara and oeprated by the Community Environmental Council, Inc. The city and county provide some technical staff, time, and financial aid. Community Environmental Council manages the program from day to day. Recycling centers are operated in Santa Barbara, Isla Vista, Lompoc, Santa Maria, and Vandenberg Air Force Base. The Program also offers curbside newspaper pickup service in 23 Santa Barbara neighborhoods.

The Resource Recovery Program has secured purchase contracts that guarantee a minimum price for recycled material. This eliminates

vulnerability to market fluctuations. Paper is sold to the Garden State Paper Company and the Allen Company, in Los Angeles County. Glass is sold to the Madera Glass Company, in Fresno. Returnable bottles, aluminum, and ferrous metals are sold to local dealers. About 18% of all potentially available paper, glass, and metal discarded in the county in 1979 is expected to be collected. A 3.5% reduction in the total county waste stream would be achieved. Energy savings are estimated at about 39,700 barrels of oil, resulting from eliminating energy use for material extraction and refining. All energy savings will occur at facilities located outside the county.

Expansion of the voluntary curbside collection service both in type of material collected and areas covered, might significantly increase the amount of recyclable material recovered. Estimates of the increase in recovered material cannot be made at this point because participation rates for an expanded program are difficult to determine. For example, a household may save newspaper for collection, but not bottles and cans. Mandatory source separation and collection is possible, but difficult to implement. Voluntary participation should be fairly high if people are made aware of the program operation and benefits through a publicity program.

Possible lack of large markets for recycled material is the major obstacle to expansion of the Resource Recovery Program. The Resource Recovery Program has found purchasers for all the paper, glass, and metals it now collects. These customers may not be able to absorb the additional material if all recyclable material were collected. Demand and prices for recycled materials are volatile, depending on the price and availability of virgin material. Most industries prefer virgin material because of its uniform quality. A material recovery program may face a surplus of material if demand decreases and no long term contracts were made with purchasers. Not only would sales revenue be foregone, but the surplus material must be stored or disposed, which imposes extra costs.

Under the right conditions, it would be possible to convert recycled paper into cellulose insulation for weatherizing homes and buildings. Using locally recycled paper to provide insulation for local buildings would reduce the energy required to manufacture paper products, to transport recycled newspapers out of the area, and to heat buildings.

Many potentially recoverable items are not currently recycled in a systematic fashion. The use of a mechanized system to separate recyclable material at disposal sites would be the most effective method, but there are technical limitations. Such a facility would require a waste stream larger than those served by any county landfill to achieve the economies of scale necessary for cost-effective operation. Magnetic separation of ferrous metals is the most uccesful mixed waste recovery system, but most mechanized recovery technologies have not been commercially proven.

ENERGY CONVERSION

Organic materials other than paper--rubber-leather, textiles, wood, food, and yard wastes--are not now recyclable, but do contain potentially recoverable energy. These wastes account for over one-third of the waste stream and constitute a theoretical recoverable energy potential of almost one trillion BTUs per year at county operated landfills. Not all this energy is realistically recoverable, given the recovery efficiencies of current technologies. MSW energy conversion can be accomplished in three ways:

- Incineration
- Pyrolysis
- Landfill gas

Incineration: Municipal waste can be burned, in either raw or processed form, to produce heat or steam. The heat or steam can either be directly used in industrial processes or for electricity generation. Refuse-derived heat and steam has been used successfully in Europe and in the U.S. at facilities in St. Louis, Missouri and Ames, Iowa. The use of incineration applications in the county, however, would be severely restricted.

A waste conversion plant must be located adjacent to the user of the heat or steam to make the most efficient use of the energy. No large users of heat or steam currently exist near county waste disposal facilities. Even more serious would be the air quality impacts of an incineration facility. The EPA and State Solid Waste Management Board estimate that large scale incineration facilities would violate federal and state air quality standards without the installation of expensive state-of-the-art pollution control equipment. Nitrogen oxides, sulfur oxides, and particulate emissions from waste incin-

eration are lower than equivalent coal or residual fuel oil combustion, but higher than distillate oil or natural gas. Such a project would have to prove its ability to meet all applicable environmental standards.

Pyrolysis: Pyrolysis is a process that produces liquid or gaseous fuel by heating MSW in a low-oxygen atmosphere. The products can be used as substitutes for fuel oil or natural gas in industrial or electric utility boilers. A pilot plant is in operation in San Diego, but has been plagued with equipment failures.

In 1975 the Loyal Environmental Systems Company presented a proposal to the Board for a 200 ton/day pyrolysis plant. The proposal was rejected for lack of environmental impact data. In 1977, Bechtel Corporation completed a feasibility study on locating a pyrolysis facility in southern California, including Santa Barbara County. The study concluded that the county had no market for the output of a pyrolysis plant. It was recommended that Santa Barbara County's participation be limited to shipping some of its MSW to a plant in Ventura County.

In addition to environmental effects similar to those for incineration, pyrolysis facilities are limited by the high cost of fuel conversion. The cost of pyrolytic oil is two to three times the price of crude oil ($40-$60/barrel versus $18).

Landfill gas: Refuse buried in a landfill produces a crude form of methane gas as bacteria anaerobically digest the organic portion of the waste. Landfill gas recovery has been successfully demonstrated in Palos Verdes and Mountain View, California.

If a well system effectively covered 50 acres of the Tajiguas landfill, total daily raw gas production might reach 75 million standard cubic feet (scf)/year. Raw gas must be processed to remove moisture and other impurities with a resulting increase in its energy value. Up to 374 million scf/year of natural gas equivalent (960 BTU/scf) could be produced from the raw gas extracted from a 50 acre field. Landfill gas from such an operation would constitute about 4% of total county natural gas consumption. Gas with a lower energy content can be produced with less processing.

Processed landfill gas can be sold directly to end users or to a gas utility to put in its gas supply pipelines. The proximity of a large SCG gas transmission line to the Tajiguas site would make the latter option attractive.

The use of landfill gas appears to be the most attractive potential source of MSW energy conversion applications. Compared to incineration and pyrolysis, the conversion and use of methane gas can be considered a realistic possibility.

Numerous considerations will influence the final determination of the landfill gas potential. The estimates on the composition of the waste stream and the energy potential should be based on conditions actually measured at Tajiguas. Waste composition, landfill depth, moisture content, air leakage, and the length of time the waste has been in place are some of the more important considerations in the determination of the energy potential.

Financing for both a detailed engineering study of the conditions at the site and for the costs of a resource recovery facility will need to be arranged. Federal and state technical and financial assistance is available but would probably not cover all costs.

SUMMARY

Resource recovery and energy conversion of MSW offer important opportunities for energy conservation. These two dimensions of the MSW process are not only closely related, but the economics of resource recovery are improved by combining the two. According to the EPA, non-combustible and non-digestible material, such as glass and metals, can be removed without reducing the energy content of the waste stream. Paper recovery reduces energy content of MSW, but the reduction is small.

Of the four more specific energy conversion processes considered, landfill gas appears the most attractive, although it may be years before these resources become available.

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AGRICULTURAL WASTES

Agricultural wastes have been identified as a significant source for energy recovery. The waste material consists of crop residue and animal manure. Just as with municipal solid waste, this agricultural material can be converted to liquid fuels such as bio-gas or alcohol.

The types and level of residues depends on the crop being produced. Santa Barbara County agriculture is characterized by a wide variety of vegetable and field crops and nuts and livestock operations. Disposal of the crop residues occurs in several ways:

- Sold
- Returned to the soil to provide nutrients for the next crop
- Used for feed
- Discarded

The largest sources of Santa Barbara County agricultural residues come from fruits and nuts (approximately 18,300 dry tons/yr) and cattle manure (approximately 15,000 dry/tons/year). In addition to these crop and animal residues, food processing operations generate an undetermined amount of residual material. These wastes and by-products have a potential for conversion to a low BTU biogas, alcohol or methane gas.

Two agricultural waste projects in California have produced biogas and methane gas on a pilot or experimental basis. The Diamond/Sunsweet walnut processing plant in Stockton has a unit which converts walnut shells to a low-BTU gas which is then used to fuel several boilers. In El Centro, California, cattle manure is converted into methane gas which is purchased by the Southern California Gas Company. Compared to these existing projects, the volume of residues in Santa Barbara County is small. Therefore, the potential for conversion to energy is more limited. The most promising application for the use of local agricultural wastes appears to be small scale energy conversion project. Such small scale technology is currently used in the Midwest to produce fuel to run an automobile engine, power a gas stove and fuel lamps, operate a gas refrigerator, and fire a space heater.

The advantage of small scale, on-site use overcomes the problems of finding a reliable market with demands matched to volume of residues, and the costs of collection, storage, and transportation would be diminished greatly. An example would be a walnut orchard operation in which prunings from the trees are collected during the winter, and stored in a dry place or immediately converted to a low-BTU gas. During the harvest season the low-BTU gas could be used to fuel a dehydrator. The key questions are whether a conversion unit could be made small enough to deal with the individual farmer's relatively low volume of residue, and whether the energy savings would make it cost effective. Santa Barbara County's walnut crop could be handled in this way.

Another potential application of the conversion of agricultural residues or food byproducts to liquid fuels would involve the conversion of molasses into alcohol at the Union Sugar Company plant. Under the right economic and technological conditions, 15,000 gallons/day of alcohol could be produced from the molasses. Alcohol produced from agricultural wastes or food byproducts can be mixed with gasoline and sold as gasohol. At a 9:1 ration of gasoline to alcohol, 15,000 gallons/day production of alcohol would be mixed with 135,000 gallons of gasoline to produce 54,750,000 gallons of gasohol per year. This could help to encourage the availability of gasohol in the Santa Barbara County area. Alternatively, the alcohol could be used to heat homes, operate farm equipment, or fuel certain appliances and lamps.

The CEC has a biomass program which includes low-BTU gas and alcohol. A major use of biomass would be to provide a clean burning fuel for electrical power generation. The Commission has set target goals of 200 MW by 1988 and 500 MW by 1991. A portion of this power would be derived from agricultural waste and byproducts. The Commission is actively involved in experimental projects such as the Diamond/Sunsweet plant, and a peach pit pulverization program designed for a boiler owned by Tri-Valley Growers.

The state legislature has affirmed its support for pursuit of biomass projects by providing a streamlined one stage Energy Commission certification process for small scale power plants, such as a conversion unit on a farm.

The State Office of Appropriate Technology (OAT) has established an Energy Extension Service, which has an agricultural section. The programs will be carried out in different parts of the state and managed an coordinated by the University of California Extension Service. The programs will include development and testing of energy saving methods for crop drying and livestock management. Conversion of local agricultural residues could be covered by these programs, with grant money available for demonstration projects.

The National Energy Act makes special provisions with grant possibilities, for the intensive development of synthetic fuels over the next ten years. Biomass conversion projects, and therefore agricultural wastes are included in this category.

These state and federal programs would help to facilitate the development of agricultural waste energy conversion programs in the county.

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SECTION III: RENEWABLE RESOURCE POTENTIAL

Reductions in the use of natural gas and electricity can be achieved by the use of alternative, renewable resources. Solar energy (including wind power), energy farming, geothermal and hydroelectric potentials and applications are discussed in this section.

SOLAR ENERGY POTENTIAL

The average amount of solar energy falling within the limits of the county is in the vicinity of 58 quadrillion BTU's yearly. If only one percent of this energy could be harnessed, this amount would be almost 30 times greater than the county's total annual consumption. The theoretical availability of this energy must be seen against local climatic conditions. The prevalence of clear skies throughout most of the year, coupled with moderate temperatures, create near-ideal conditions for capturing and utilizing this solar potential (see Appendix D for Solar Climate data). The extent to which the large theoretical potential of solar energy can actually be used will be determined by more specific solar processes and application.

SOLAR PROCESSES

The definition of solar energy and solar applications can take many forms. While no one definition has been generally agreed upon, it is important to specify the forms of solar energy and applications considered in this study. In a sense, all forms of terrestrial energy can be considered 'solar,' since all energy on earth was originally triggered by solar processes. This study will confine itself to three broad areas of solar energy utilization:

- Solar-thermal processes, whereby sunlight is collected and transformed into heat energy;
- Photovoltaic processes, whereby sunlight is directly converted into electrical energy; and
- Wind processes, whereby winds, which are caused by atmospheric heating, can power mechanical devices for the production of electricity and for pumping.

Each of these processes - solar-thermal, photovoltaics and wind can be used in a variety of applications. For example, solar-thermal energy can be used for heating buildings or, under proper conditions, can generate

steam to operate electrical generating boilers. Similarly, wind energy which is primarily mechanical, can directly operate pumping equipment or it can be used in wind generation systems.

SOLAR ACCESS

Before surveying the applications of solar energy, the problem of availability must be examined. When a new oil field is found, it is necessary to arrange for that oil to arrive at it's point of use. In the same way, we must assure that solar collection devices are properly sited to receive the incoming energy from the sun. Furthermore, assurances must be given that the site is protected from obstructions which would block the collection function. Solar access describes the required and unobstructed exposure to the sun that a solar collector needs to operate properly.

Solar access can be a somewhat complicated issue, because it must account for a number of factors. Among these factors the most important are:

- the constant change of the sun's place in the sky at different times of the day, and different times of the year;
- the tilt and orientation of the collection surface;
- The existence or future development of structures adjacent to the collection surface;
- local topographical features; and,
- the presence and type of vegetation adjacent to the collector.

In short, the collector must not be shadowed during the hours of peak collection.

The vast majority of the sun's energy is available between the hours of 9:00 a.m. and 3:00 p.m. The sun's azimuth is the position of it's path as it moves from sunrise to sunset. Thus, the sun comes over the horizon at a different point with reference to true east, each month of the year. The sun's altitude refers to the height of its path with relation to the horizon. With this information in mind, a "solar window" can be constructed which defines the area above a collector which should be unobstructed. This window is bounded by the sun's highest (June 21) and lowest (December 21) altitude, and by the range of its yearly azimuth

and 9:00 a.m. and 3:00 p.m. (see Figure VI). Solar access protects this "window" from a variety of possible obstructions.

In 1978, two state laws went into effect which help to protect access. The first of these, the Solar Shade Control Act, prohibits the planting of any tree or shrub on property adjacent to a previously installed solar collector which would block the collector during 10:00 a.m. and 2:00 p.m. The second law, the Solar Rights Act, specifically recognizes the legality of easements for solar access between property owners, prohibits ordinances or covenants restricting the use of solar systems, and requires tentative subdivision maps to provide for solar access.

The specific issues of solar access change depending on the specific solar application. For example, a roof-mounted, 40 square foot collector has different solar access requirements than vertical, south-facing windows used for space heating. A number of local communities, including the cities of Davis and Los Angeles, and the counties of Santa Clara and San Diego, are in the process of promulgating their own access legislation which responds to local conditions. While it is incumbent upon county and city planning departments to enforce the provisions of the Solar Rights Act dealing with subdivision maps, the state law does not recognize access problems below the subdivision level.

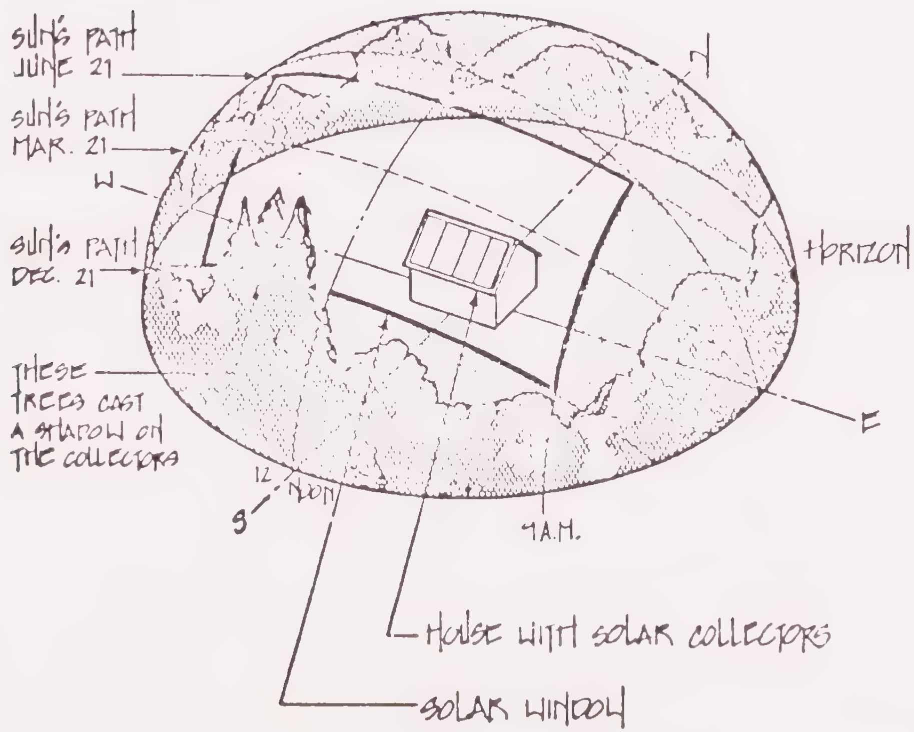
In many respects, access problems will be minimal in the county. Most areas of future growth, particularly in the North County, will be in fairly flat and open areas. Further, the low rise nature of future buildings reduce shading, hence, access problems. Nevertheless, it is still incumbent upon the county to identify its access requirements clearly. Without this clarification, the solar potential becomes limited, especially in the retrofit market and other areas not covered by existing state legislation.

SOLAR APPLICATIONS

At the present time, each application of solar energy has reached a different level of "technological maturity," commercialization, and implementation. Certain applications are significantly more developed than others, and in the near future, these applications are most likely to make an impact on energy use in the nation, the state, and the county.

FIGURE VI

A "SOLAR WINDOW" WHICH ASSUMES YEAR-ROUND SOLAR ACCESS



Five solar technologies will be discussed in this study as the most advanced and ready for some degree of implementation. These five are:

- Solar water heating
- Solar space heating and cooling
- Industrial process heat
- Photovoltaic production of electricity
- Wind generation of electricity

Solar Water Heating: Solar heating of water in potable water systems is the most mature and commercially developed application of solar energy. The use of solar systems for heating domestic water was prevalent in Southern California prior to the discovery of natural gas deposits in the 1930's. The availability of this gas undermined the economic attractiveness of these early solar water heaters.

In various regions throughout the world, solar water heating continued to develop in the absence of low-cost fossil fuel energy supplies. Thus, solar water heating technology has continued to develop for the greater part of this century. In the last ten years, a great deal of activity has accrued in the testing, development and marketing of solar water heating systems. At the present time, an expanding solar industry exists throughout the United States. It is interesting to note that approximately two-thirds of the solar collector manufacturers are located in California. Major manufacturers of other system components also operate in the state. Within the county, a major solar collector production facility is located in Santa Maria. The potential for a flourishing local solar industry has significant economic and employment impacts that cannot be overlooked.

Several factors contribute to the potential of widespread solar water heating use in the county. First, the favorable solar climate conditions throughout the county mean that smaller and less costly systems can be used. The favorable climate conditions also allow for a higher overall percentage of energy supplied by the solar system. Typically, a properly installed and functioning system will supply 70-80 percent of the total domestic hot water (DHW) energy. Finally, the widespread use of solar water heating will contribute to reducing the county's reliance on conventional energy supplies. If at any time, shortages of conventional

fuels develop, the existence of in-place solar energy systems can cushion the effect of these shortages.

What is the energy saving potential of solar water heating? The Energy Commission has determined that approximately 80 percent of existing residences statewide could successfully be retrofitted with solar DHW. For new construction, this figure is about 90 percent.

Residential DHW consumes about 7.5 percent of the total energy use in the county. Adding the amount of energy used to heat potable water in the nonresidential sectors, total water heating energy end use consumes in excess of 12 percent of total energy use. If solar water heaters were used in 80 percent of all water heating systems, and if these heaters supplied 70 percent of the water heating BTU's, total energy consumption would be reduced by about 7 percent. At current consumption levels, this would amount to a savings of 6.3 million therms of natural gas and 15.3 million kWh electricity for the residential sector alone. At current energy costs, the value of this energy savings is about 2 million dollars. As the price of energy escalates, even more savings will be realized. Also, the energy displaced by solar would be available to lower priority customers (e.g., industrial and commercial users), during periods of curtailment.

The savings for individual households can be determined from current consumption patterns (Table IV, Appendix A). Single family residences average anywhere from 262-331 therms of natural gas to 4,876-6,377 kWh of electricity for water heating, depending upon whether they have dishwashers and washing machines. Solar would displace 183-232 therms or, 3,413-4,464 kWh. At current prices, annual savings would range from a low of $38 to a high of $219, depending on the source of fuel, and the number of appliances in use.

Any discussion of solar energy applications must include the relevant economic considerations. Although some people will purchase a solar system to "be independent of the utilities," or for environmental reasons, most people will consider solar only if it is likely to be competitive with conventional energy. The economic choice <u>between</u> the conventional systems (electric or gas) can be based entirely upon current fuel prices,

since the costs of the heating systems themselves are comparable. The choice to go solar must be made on a different basis, since most of the "fuel" is free, while the equipment is a significant expense.

Basically, a solar energy system will be less expensive than a non-solar system if the fuel savings are greater than the finance payments required to buy the solar system. A problem with this comparison is that it is difficult to take into account rising fuel costs. Also, there are other items affecting the economics of solar heating, such as property taxes, tax credits, insurance, and maintenance. A more realistic approach is to use the "life cycle cost" method which takes into account all future expenses. This method provides a means of comparison of future costs with today's costs, by reducing all costs to the common basis of present worth, that is, what would have to be invested today in order to have the funds available in the future to meet all of the anticipated expenses.

The costs of a solar water heating system falls upon the individual home-owner. It is likely that a professionally installed solar DHW for a single family home will cost between $1,500-2,100. For this amount, the purchaser will get a system that will provide at least 65-80% of the annual water heating BTU's (see Figure VII). Compared to the use of an electric hot water heater, an active solar hot water system is cost effective. In many cases, the solar system costs compare favorably with natural gas.

The cost effectiveness of a solar system can be significantly improved a number of different ways. First and foremost, if the homeowner is able to install the system, the first costs of solar can be reduced by as much as $500. Secondly, there are alternatives to an active flat plate collector system. These alternatives, which combine the collection and storage functions, are somewhat less efficient, but are considerably cheaper. One example is the "breadbox" water heater (see Figure VIII), which can be owner-constructed for between $100-$300. If properly constructed and installed, these units are also eligible for income tax credits. It is possible to have a solar heater with "out-of-pocket" costs under one hundred dollars, which can supply approximately 50 percent of a household annual water heating energy demand.

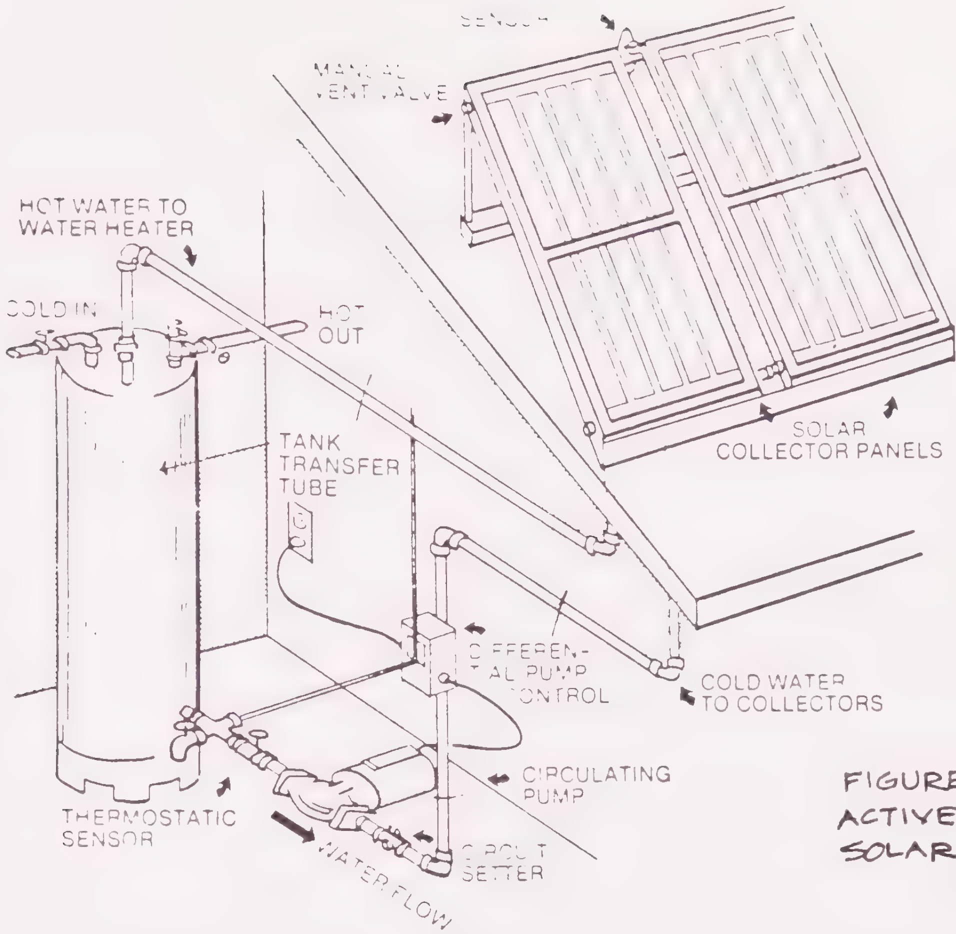
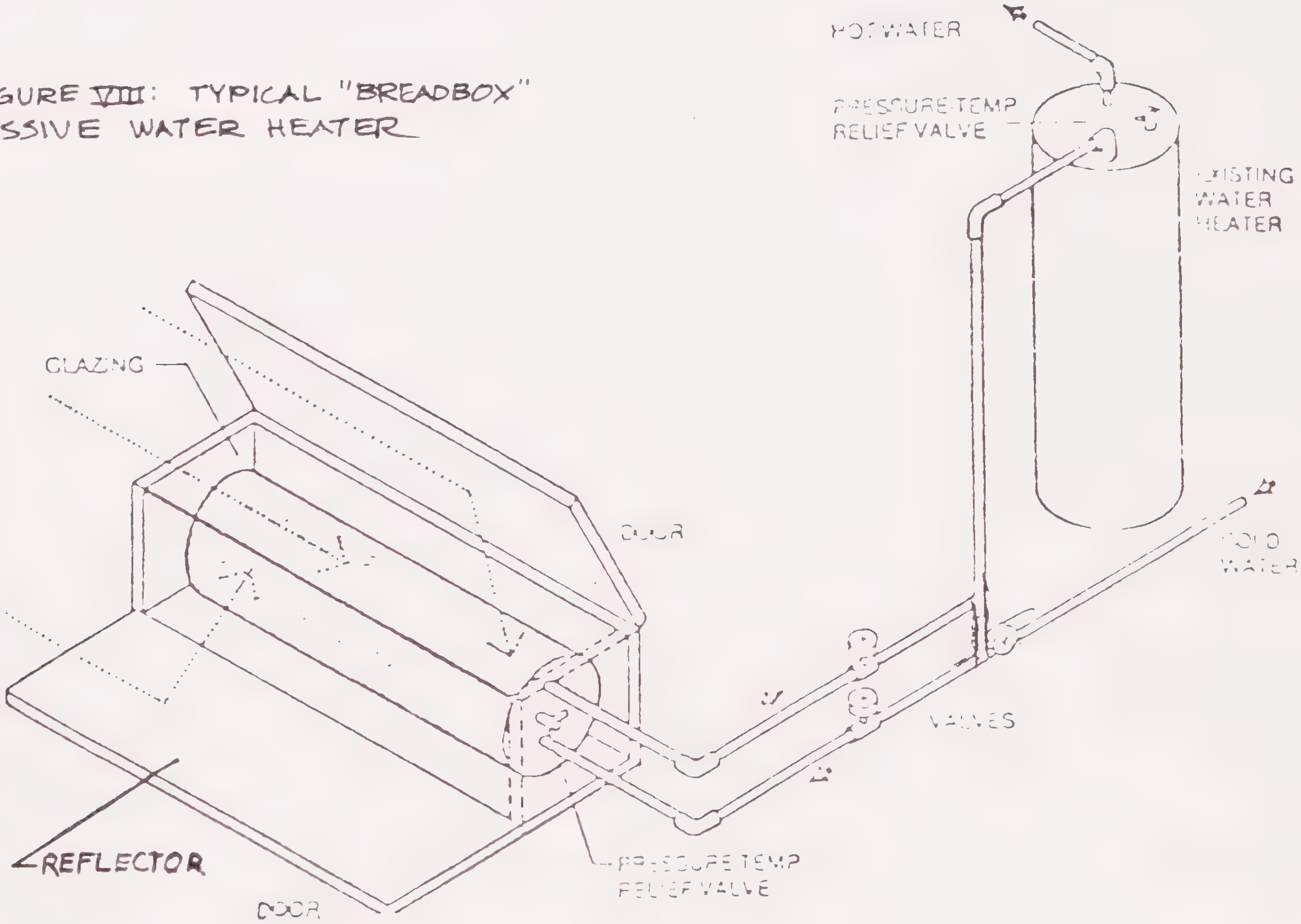


FIGURE VII: TYPICAL ACTIVE FLAT PLATE SOLAR COLLECTOR

FIGURE VIII: TYPICAL "BREADBOX" PASSIVE WATER HEATER



The Community Action Commission Incorporation (CAC), a local community action program, is designing, constructing and installing breadbox water heaters for low income households in Santa Barbara County. By experimenting with different design approaches, the CAC has been able to build these systems in the $100-$150 price range (see Appendix D for materials breakdown). The CAC intends to install 120 units in 1980. An additional result of this program will be the training of 15 CETA participants in solar technology skills.

The main constraint to the use of solar water heating - and space heating as well - is the initial costs that the individual user must bear. Even with tax credits, the homeowner must be willing to dedicate a large amount of money in exchange for future benefits. Under a voluntary incentive program such as the tax credit, many homeowners are willing to pay $2,000 or more for a solar water or swimming pool heater. However, many more homeowners are not in a position or are not willing to accept this first cost burden. In new housing, this burden is not so great, since the costs of solar can be integrated into the overall costs of the mortgage. In a retrofit situation, the interest on a home improvement loan largely negates the savings that accrue from solar, at least during the period of the loan.

Low or no-interest loans can be used to remove the first-cost barrier from the homeowner. Senator Omer Rains introduced legislation following the Sycamore Fire, which made low-cost loans available to fire victims who were rebuilding in the fire area. President Carter, as part of the national energy program, has proposed the development of a solar bank which would make low-interest loans available. The Tennessee Valley Authority (TVA) has established a program of lending their customers the money for a solar water heater. The loan is paid back through the monthly service bill.

Several local jurisdictions are investigating the creation of special municipal solar utilities (MSU) to sell, lease, and maintain solar systems. These MSU's would remove the first-cost barriers, and help remove consumer uncertainties about the use of solar systems.

<u>Space Heating/Cooling</u>: The utilization of solar energy for space heating

represents a well-developed technology that has its origins in ancient cultures who had to utilize the materials at hand to temper the extremes of climate. The climate of Santa Barbara County is particularly well-suited for solar space heating applications. While a moderate amount of solar energy is necessary for year round water heating, climatic conditions are more critical for use of solar for winter space heating. Winter skies in the county are exceptionally clear (see Appendix D). Moderate temperatures place light loads on heating systems, compared to other parts of the nation. Average high temperature during January, the coldest month - is 55°F. while the average minimum temperature is 41°F. Consequently, heating systems are not working with extremes of temperature between outside conditions and inside comfort.

There are two generic types of solar space heating systems; active systems and passive systems. A third system - hybrid--combines aspects of the first two. Active space heating systems are similar to active water heating systems (see Appendix D). They utilize flat-plate collectors, storage medium and a variety of pumps, valves, and controls to move the heat from the collectors to storage, and then into the heated space.

Passive systems are generally separated from active ones by two characteristics:

- passive systems do not use components which require conventional energy to operate them; and
- passive systems usually are part of the structural components of the building.

Passive techniques commonly include the use of south-facing windows, skylights, masonry walls to store absorbed heat, and attached sun rooms or solar greenhouses (see Figures IX and X).

Passive and active systems also have different potentials for retrofit and for new construction. It is often thought that passive techniques are more applicable to new construction. In reality, this distinction is not the case. Active systems require significant amounts of roof area with fairly unobstructed south-facing roofs. This space may not be available. The existing heating system may not be easily interfaced with the solar. Finally, active systems tend to be very expensive. Installed costs for a system utilizing 250 square feet of collector may cost from $5,000 upwards.

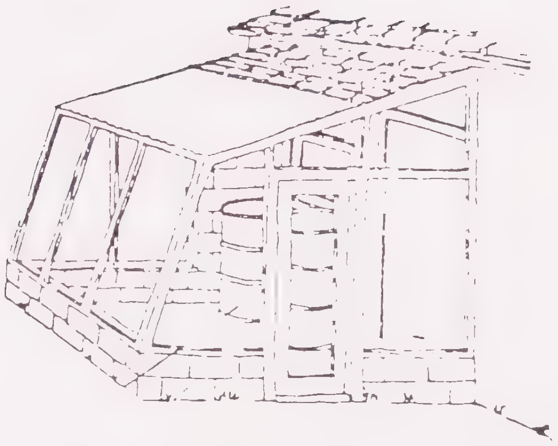


FIGURE IX
ATTACHED SOLAR GREENHOUSE

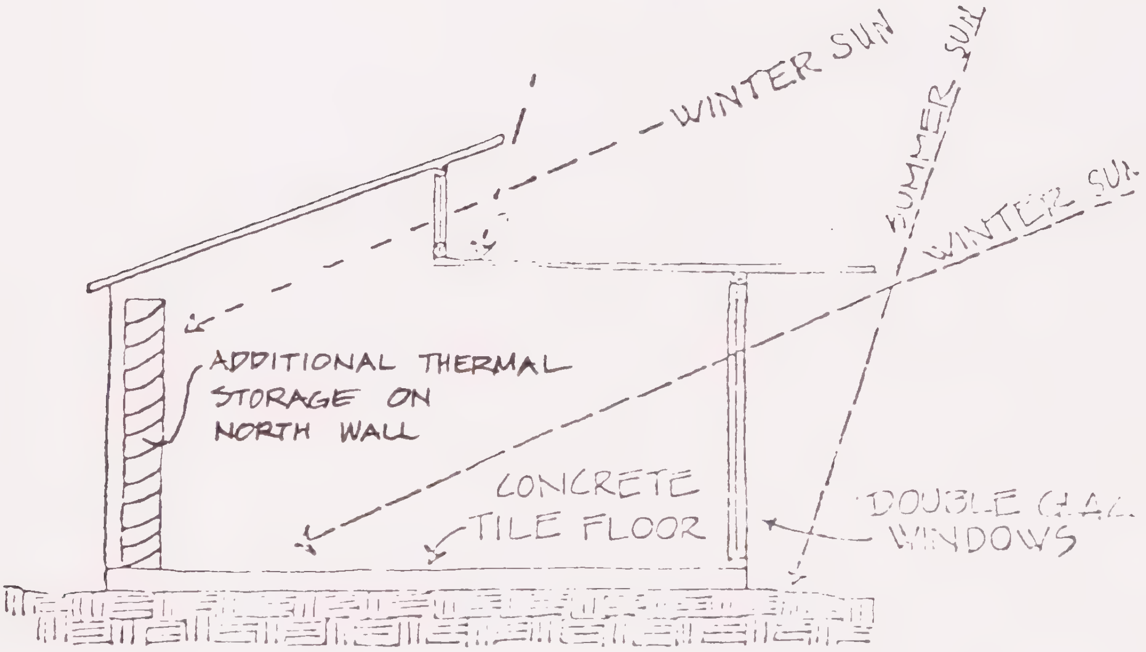


FIGURE X
BASIC PASSIVE DESIGN FEATURES

Passive systems can be added to existing construction. Increasing the amount of glass area on a south-facing wall can significantly add to daytime winter heat gain. Perhaps the most effective passive retrofit is the installation of an attached greenhouse-sunroom. Such additions may cost as little as $5/sq. ft., and can provide as much heat as an equivalent square footage of flat-plate collectors. SUNRAE, a solar advocacy group based in Santa Barbara conducts workshops for do-it-yourself greenhouse construction.

In new construction, the choice between active or passive solar for space heating is again influenced by a number of factors. Active systems can impose fewer constraints on a choice of building materials that will make up the structure. Active space heating systems can be readily interfaced with solar water heaters. On the other hand, active systems require large roof areas for collector mounting, extra space for the heat storage system, and as with retrofits, are expensive.

Passive systems have a special attraction for new construction - they are integrated into the building fabric itself. South-facing windows and skylights act as solar collectors. Other techniques use the walls themselves as collection surfaces. Passive houses are constructed using the principle of thermal mass (i.e., using dense building materials which can soak up and store large amounts of heat). Examples of these include; brick walls, masonry fireplaces, slab foundations, water contained in units that are integral to the building, and various forms of decorative tile.

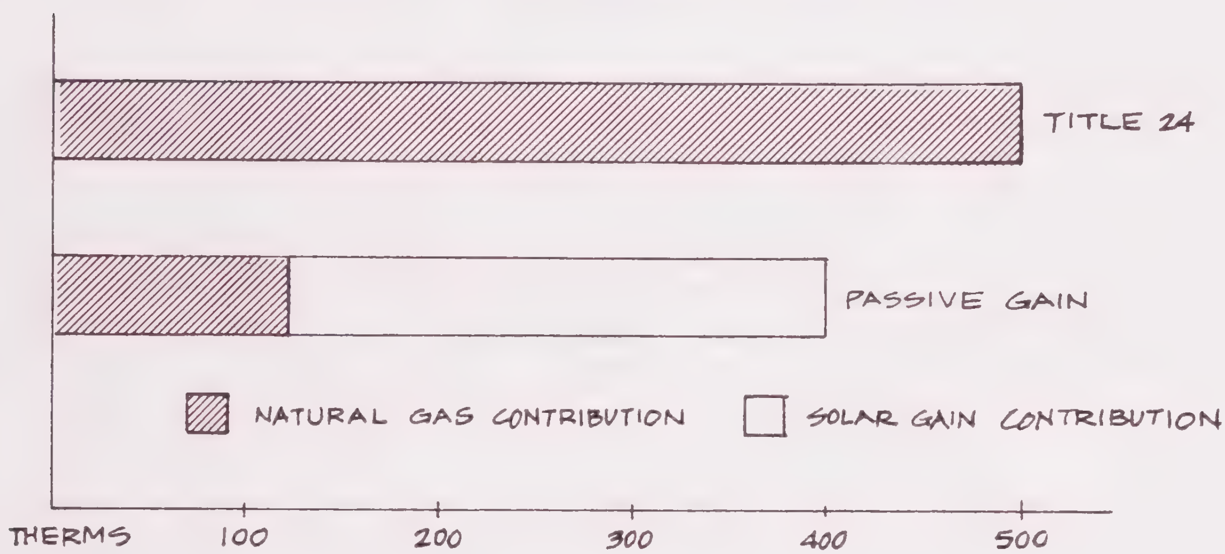
These and other passive features can be, in most casts, readily adapted to familiar building materials and conventional construction techniques. When the passive components are integrated into the structure, costs are significantly reduced, because the same component performs double duty as a structural component and a solar component.

Both active and passive systems require some sort of conventional back-up. It is difficult to provide a 100% solar heating system for several reasons. The additional space and components required significantly increase initial costs to the point where life-cycle costs become less favorable toward solar. Secondly, additional system size requires additional storage capacity. This again places both physical and economic constraints on

the system. Finally, it is unrealistic to think that any given size solar system is a guarantee that no additional heat input will be required during an unusual cold period. As a consequence, every system should have an appropriate, efficient and economical back-up system, which may be natural gas, propane, solid fuel, or less desirable, electricity.

A solar space heating system capable of providing at least 70% of the annual heating energy is a reasonable target. In reality, in any given month, such a system might provide anywhere from 60-100% of the heat demand. An extremely well-insulated solar house might require only 1/3 the quantity of conventional energy than a house currently constructed which meets existing building standards (see Figure XI).

FIGURE XI
COMPARATIVE SPACE HEAT REQUIREMENTS
(TITLE 24 AND PASSIVE GAIN)



The cost of solar space heating will vary according to type and the percentage of heating it provides. Active systems will cost a minimum of $25-$40 per square foot of collector installed costs. Passive systems are considerably less. In new construction, passive may add $1,000-$2,000 to a new house. A retrofit greenhouse might cost anywhere from $500-$1,200. As with solar water heating, space heating systems are fully eligible for state and federal tax credits which effectively reduce the costs of most

systems by more than one-half.

Solar space heating for commercial/industrial buildings presents both opportunities and constraints. Minimal storage is required, since most activities in these buildings are day use only. Retrofit space heating applications on existing structures is often limited. Roofs may be poorly oriented or shaded, and they are usually cluttered with existing mechanical equipment, vents, etc. Ground space is also at a premium. However, new structures are not faced with these constraints, and can definitely be planned to utilize solar for both water and space heating usage.

High Temperature Solar-Thermal Energy: The industrial sector consumes large amounts of high temperature thermal energy. This heat is generally called process heat. Industry requires this heat for a variety of processes at a variety of temperature ranges. Three distinct ranges of heat are required:

- under 212°F
- between 212°F and 350°F
- over 350°F

When the required temperatures are above 350°F, it is usually above 1000°F. Industries requiring these higher temperatures include; petroleum refining, blast furnaces for metals, and cement. Many industries use thermal energy at temperatures under 212°F.

Food processing, metal plating, and paper products industries commonly use process temperatures in this range. Even when temperatures requirements are low, it is common to find the heat supplied through a boiler producing steam at 350°F.

Conventional solar energy systems, as described in the preceding section, are well fitted to provide heat for a wide variety of industrial processes. When temperatures are between 110°F and 212°F, active flat-plate collectors can often supply the total thermal energy. In other cases, the solar system can operate in a pre-heat mode, which feeds the solar heated water into a flash boiler for a boost up to the required temperatures.

When temperatures in excess of 212°F are required, more advanced technology

is required. The usual approach is to use a type of solar collector called a concentrating or focusing collector. Unlike flat-plate collectors, concentrators have the ability to "track" the sun as it moves through the sky. The tracking and focusing nature of these collectors allow them to produce considerably more thermal energy at higher temperatures. Concentrators are commercially available, but cost, along with associated equipment can be prohibitive.

Three major industrial groups consume most of the energy in the county's industrial sector. Specifically, these are the oil industry, sugar processors, and diatomaceous earth (d.e.) mining.

THERMAL END USE REQUIREMENTS

	Under 212°F	212-350°F	Over 350°F
Sugar	22%	73%	57%
Oil Refining	Negligible	Negligible	95%+
D.E. Mining	0	0	100%

The approximate temperature range for existing concentrator technology is under 350-400°F. Thus, the most likely application of solar thermal is in the food processing industry. Food processors consume approximately 1,000 mmcf/yr. of natural gas. Union Sugar accounts for over 3/4 of this consumption.

Concentrators need clear skies to absorb solar energy, while flat-plate collectors can also gather energy during periods of moderate overcast. This limitation on concentrators must be considered when applying them to a specific site. However, it is likely that concentrators could provide at least 50% of the thermal energy between 212-350°F, and in excess of 75% for uses under 212°F.

Both the federal and state government are exploring the use of solar energy in one more industrial process. This process is the steam injection technology used to force the flow of heavy oil such as that found in the North County. Approximately 4.9 BCF/yr of natural gas and 100,000 barrels/yr of oil are used to fire steam generators for oil extraction.

A typical steam generator produces about 20-25 million BTU/hr. A solar system either produces this much energy, or functions in a pre-heat mode.

Additionally, a storage capability in excess of 400°F is necessary. The Department of Energy intends to operate a solar steam injection system by the early 1980's. The Santa Maria area has been targeted as a site meeting the basic technical criteria. Solar steam injection is attractive because it frees up fossil fuels used for the production of energy, and makes that fuel available for other uses.

Solar and Wind-Generated Electricity: Two well-known technologies can produce electricity from the sun. The first method is a direct conversion process called photovoltaics. Solar cells become commercially available as a result of the U.S. Space Program requirements for remote generating systems. The other solar technology is wind-electric generation. The connection between solar energy and wind-electric may not seem apparent, but it must be remembered that winds are the results of thermal gradients produced by the sun's energy acting on the atmosphere.

Solar electricity in either form can develop along two lines. One is to emphasize a utility sized central-station plants capable of generating power in the megawatt range. The other way is to develop individual decentralized units located at the point of use.

Centralized photovoltaics require large land areas. A 1,000 MW(e) system requires at least 25 square miles of photocells alone. Smaller centralized systems would of course, require proportionately less space. Individualized systems may offer more attractions. A single family residence, which does not use electricity for space and water heating, would require a solar cell array approximately 14 x 40 feet. Inidividual systems would also be ideal for more remote application, where the cost of erecting and maintaining transmission lines (along with the associated transmission losses) significantly raises the cost of conventional electricity. On the other hand, if individual systems are not connected to the utility grid, expensive storage systems are required.

At the present time, photovoltaics are prohibitively expensive. For example, an array sized to meet the needs of a single family dwelling costs at least $35,000. This is based on a $10/watt cost; currently this is the lowest price for silicone solar cells. However, the Department of Energy has established a commercialization program which will bring the cost down to $ .50/watt by 1990. At this point, solar cells would be an overwhelmingly attractive proposition.

Climatic conditions in most parts of the county provide good opportunities for the use of photovoltaics. The foggier, coastal areas have some seasonal limitations, but this can be corrected through increased array size or larger storage.

The potential for photovoltaics is great. When price reductions occur, photovoltaics can make a large contribution to the county's electrical demand.

Wind-electric technology is, in many ways, more developed than photovoltaics. Wind-electric generators have been in use since the beginning of the century. Most of these systems have been small decentralized units, although generators in the megawatt range have been operational. Prior to the rural electrification program of the 1930's, many farms used on-site wind electric. A well developed wind generator industry thrived during this period.

Capital costs for wind electric can be well under $1,000/installed kilowatt making wind-electric cost competitive with the more expensive forms of conventional generation.

Current efforts with wind electric are directed toward both on-site and centralized systems. The Energy Commission and DOE are developing centralized wind electric systems. The most promising sites in the state are the Pacheco Pass in central California, and the San Gorgenio Pass near Palm Springs.

The most promising wind sites for economical and reliable power generation must have a mean annual wind speed of 14 mph or greater. The CEC has conducted a wind siting survey to target potential wind sites throughout the state. The Point Conception - Point Arguello area is considered a "fair" wind site, meaning that average annual wind speeds are in the 11-14 mph range.

The installation of a 100-megawatt "wind farm" would require approximately 70 acres. Land area between the wind-generators could be used for stock grazing. These wind turbines would have 250-P+ rotors with each madine producing 2 megawatts. Because of their large size, wind systems will be sited in remote locations. For this reason, Point Conception should be considered as a potential wind farm site.

Small scale wind electric can take advantage of micro-climatic variations of wind velocity. Consequently, there may be site-specific wind potentials along ridge lines, in canyons and gullies. This is important for the individual who sees advantages to small decentralized wind turbines. Costs are still a barrier. A complete wind system will cost at least $1,500/kilowatt. At the present time, approximately 15 residential wind systems are operating in Hollister Ranch area near Point Conception. The average costs of these systems is $2,000 to $15,000. These installations are examples of where high wind speeds and the prohibitive cost of extending power lines make wind electric feasible.

The most attractive use for wind electric is in remote areas where the cost of bringing in electric lines may be prohibitive.

Mechanical energy can also be extracted from the wind. Windmills used for irrigation water pumping are the most common example of this. Pumping end use consumes a great deal of electricity in the agricultural sector. In many cases, it may become cost effective to replace these electrical pumps with mechanical pumps.

SUMMARY

A very large potential for the use of solar energy exists within Santa Barbara County. This potential is currently greatest in solar thermal applications. In excess of 70 percent of all space and water heating energy could be provided by solar. Solar electricity may make a future contribution when prices are significantly reduced. Wind electric technology can make a contribution in certain parts of the county.

At the same time, there are constraints to the utilization of this potential. Many of these constraints are largely economic, yet a variety of strategies can overcome economic barriers. New residential construction has the least constraints, since problems of cost and access are easily dealt with. Retrofit applications are more difficult, but still offer the greatest near-term potential, since existing structures are not particularly energy efficient, and they do form the overwhelming percentage of future building stock, at least to 1990. Other constraints include public credibility, lack of clear policy on the part of public officials in regulating the use of solar, and the undeveloped state of the solar industry.

Undoubtedly, these problems will be solved, one by one, as solar becomes a more attractive energy source. This is bound to happen as conventional fuels become more expensive and less available. If the past few years are reliable indicators, solar energy is becoming increasingly acceptable to the public, to government agencies, to political officials, and to many segments of industry and commerce.

The current Solar Development Program (SDP), organized by the CEC attempts to encourage and speed this growth of solar energy. The SDP is especially directed toward three areas:

- Solar water heating, including:
  a) installation of solar water heaters in 50% of new residential construction by 1985
  b) annual retrofit of 50,000 units by 1981

- Solar space heating, including:
  a) space heat installation in 20% of new building by 1982
  b) annual retrofit of 50,000 systems by 1985
  c) passive solar incorporated in 50% of new construction by 1983

- Wind electric program to bring on-line 500mw of turbine capacity by 1987

Other components of the SDP include; an outreach/public information program, provision of economic analyses of solar systems, and the development of the State Testing and Inspection Program for Solar Equipment (TIPSE). The latter program certifies the performance of flat-plate collectors.

It is too early to tell if the SDP will achieve its goals at the specified date, although there is reason to believe that without more aggressive policies and programs, these goals will not be met. Even if goals are achieved, the results will impact upon a small percentage of state energy use. For example, if all goals for residential solar were achieved, less than four percent of all dwelling units would be affected. It is for this reason that local action is both necessary and can also result in greater utilization of solar energy. Local ordinances and other action programs will promote levels of solar implementation much higher than state goals. Additionally, programs developed at the local level can be specifically tailored to local needs, rather than general programs promoted by the state

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ENERGY FARMING

Plants are able to convert sunlight energy by photosynthesis into biomass, which can be used as a source of fuel. The fuel conversion process could be very similar to the technology used with agricultural wastes. The specific production of biomass for fuel could occur on energy farms. There are basically four types of energy crop systems:

- Annual energy crops (field crops)
- Aquatic energy farms
- Kelp
- Siviculture (trees)

The land-based energy farm would include the use of conventional crops on prime agricultural land, short rotation tree farms on marginal lands, and the cultivation of novel and native species of plants. The aquatic system involves production of biomass in a microalgae form as an integrated part of a municipal or county waste treatment system. The kelp concept is the least well developed, but an experimental project is underway near Newport Beach. It consists of cultivating certain species of kelp on the open ocean on artificial supports. The kelp would be harvested and processed to produce a form of natural gas. Each of these energy farming projects could play a role in local renewable energy supplements to fossil fuels.

Annual Energy Crops: The type of crop and amount of acreage for field crops is in a constant state of flux. The farmer's choices of crops and amounts of acreage are determined by many factors such as the availability and cost of water, the energy costs of maintaining an agricultural operation, and the market value of each crop. Sorghum and sugar beets which together constituted less than 1% of 1978 county agricultural production have a potential for energy conversion. Currently, the sugar beets are marketed commercially, and sorghum is used as a cover crop.

The major constraints to the farming of annual energy field crops appear to be the issue of competition for land between energy and food, and the availability of water. On a practical basis, it is extremely unlikely that much land which is currently available for growing food would be converted to crops solely for energy production. Energy farming shares many of the constraints found with the use of agricultural wastes for

energy. These include uncertainty over the means of collection, storage, transportation, marketing, problems with a seasonal product vs. needs for reliable year round supply, and weather variations.

Aquatic Energy Farms: The aquatic systems of microalgae are attractive as high energy crops, because of potentially high yields, the ability to grow in saline or brackish water, and the ability of some species to fix nitrogen (thereby reducing production costs and producing nitrogenous fertilizers). A major technical problem is the difficulty in harvesting the microalgae. Although algae has been grown for many years in some sewage treatment ponds, it is part of the treatment process, and not harvested for energy purposes. The amount of surface area needed to grow sufficient algae for energy production could exceed the amount of land available.

Kelp: Ocean farms of kelp have the potential for large scale fuel production, but harvesting can be a problem in this case also. Other potential problems are the effects of weather, natural predators, and possible damage from ship traffic. As the results of the Newport Beach experimental project become available, the actual limitations and practical energy potential of kelp farming should be more apparent.

Siviculture: It appears that the most practical, expedient application of energy farming in the county would be a crop needing little water that would not take up productive agricultural land. Planting eucalyptus trees on some of the vacant, sloping (or otherwise marginal) land would be ideal, because of eucalyptus' low maintenance requirements, rapid growth, drought and pest resistance, and fairly high BTU content (8,000-8,500 BTU/dry lb.). The yield per acre ranges from 6-20 dry tons/acre yr., depending on the quality of the land. Blue Gum has been found to be the highest yielding eucalyptus, and can grow in areas such as Santa Barbara. Energy products which can be derived from eucalyptus include alcohol, charcoal, and firewood for space heating.

The California's Energy Commission's Biofuels Office has a broad program which includes energy farming. As far as can be determined, there are no specific research or demonstration projects in the county at this time, but the Commission is committed to encouraging energy farming as an

innovative renewable resource. The Biofuels Office funds feasibility studies and demonstration projects, so the Commission would be a possible source for an energy farming grant.

Santa Barbara County could apply for such a grant in conjunction with an interested land owner, or offer a land owner information and assistance with a grant application. A local energy farming project could be an uncomplicated, economical supplement to the county's energy resources in a fairly short period of time.

REFERENCES

"A Preliminary Assessment of the Potential for Producing Biomass from Terrestrial Solar Energy Plantations in California." TEKNEKRON, INC. Berkeley, CA, 1978.

"Energy Farming" California Energy Commission, 1978.

Energy Choices for California (California Energy Commission, March 1979, p. 205).

Santa Barbara County Agricultural Commissioner 1978 Crop Report

GEOTHERMAL

Geothermal energy is the natural heat of the earth. The use of this energy involves well known technology for purposes of generating electricity, space heating and water heating. The natural heat of geothermal resources has been used for decades to heat homes and water in California, Oregon, and other western states. Electricity generation is commercially produced in the Imperial Valley, east of San Diego, and at the Geysers in northern California. The state and the utility companies have identified geothermal power as a major source of energy. It is expected to contribute about 2,500 MW of electricity in California by the late 1980's.

The United States Geological Survey has identified five known geothermal reservoirs in Santa Barbara County which have a heat range of 67°-120°F. Each area has a hot spring formation. It is possible that heat from each of these reservoirs could contribute to the county's energy resources, but the development possibilities appear limited. At the relatively low temperatures found here, water heating and space heating would be the most likely applications. The user of the heat would have to be at the site however, because so much energy would be lost in transportation. Currently these areas are well adapted for low-key recreational use. Extensive commercial development on the scale of a resort could result in environmental impacts that would negate the value of the additional energy. Commercial development of the Sespe area would be further precluded because of its location adjacent to the Sespe Condor Reserve. Federal law prohibits development in or adjacent to areas set aside for endangered species, such as the Sespe Condor.

Electricity generation from geothermal reservoirs is dependent upon higher temperatures than those available from the known sources in the county. Unless further exploration leads to the discovery of such new reservoirs, the use of geothermal energy for electrical power generation cannot be expected.

The potential for geothermal energy in California is significant. For the county, however, the potential is limited by the low temperature ranges of known reservoirs, and the location of these reservoirs.

REFERENCES

1. Energy Choices for California (California Energy Commission, 3-79) pp. 189-196.

2. USGS Professional Paper No. 492, 1965.

3. Geothermal Policy Report, (California Energy Commission, 3-78)

HYDROELECTRIC POWER

Electricity can be produced by intercepting the force of falling water as it goes over a dam or emerges from a tunnel. The water's force turns the blades on a turbine attached to an electric generator, resulting in hydroelectric power production. In California, this is a widely used technology, which utility companies include in their electricity resource bases for residential, commercial, industrial and agricultural consumption.

The state, the utilities, and local water districts have identified small scale hydroelectric projects as a significant source of pollution-free power. There are many possibilities for power development at existing dams, canals and pipelines. None would require new construction of a dam or other facilities. Municipal water districts often own the facilities, and usually sell any power generated to the electric utilities.

The City of Santa Barbara has recognized the local benefits in adding small scale hydroelectric equipment to existing facilities. The City, through the Public Works Department, plans to install electric generating equipment downstream from the city-owned Gibraltar Dam, with a potential for 1.4 MW of power. These plans are at the federal licensing stage now, with local review to follow.

The State Department of Water Resources has identified several other potential sites for small scale hydroelectric production in the county. They include; the Picay Pressure Break (a pipeline), and the Bella Vista Reservoir on the Santa Ynez River, the Juncal Dam at Jameson Lake, and possibly the South Portal of the Doulton Tunnel. The total power potential is estimated to be in the area of .36 MW (360 KW). There are no plans for development at this time, but it remains a possibility. The Goleta Water District has identified a potential site at the North Portal of the Tecolote Tunnel. There are no current plans for development.

REFERENCES

Personal communication with Mr. Mike Hopkins, City of Santa Barbara Public Works Department, 9-79.

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SECTION IV: PROJECTED ENERGY CONSUMPTION

The preceding discussion of the conservation and renewable resource potentials suggest that a number of factors will shape future energy consumption patterns. Perhaps the most significant factor concerns the effects of various governmental and utility programs designed to reduce the consumption of conventional energy supplies. The central question posed to local governments is whether the existing programs are sufficient in terms of maximizing the potential for reducing local conventional energy consumption. In order to answer this question, it is necessary to: a) project future energy consumption, incorporating the effects of existing programs; and b) identify the additional reductions in consumption associated with supplemental local energy conservation and renewable resource programs.

This section assesses the effects of existing programs on future energy consumption in the county. The effects of adopting a series of local initiatives are discussed in Part III of the Energy Element.

Every two years, the California Energy Commission is required by state law to establish a forecast of future energy demand in California. Because of this mandate, the CEC has developed a forecasting methodology which incorporates a wide range of assumptions of future conditions in California. The most recent CEC forecast, subject to revision prior to adoption in late 1979, constitutes the basis for projecting local energy consumption. Since local conditions do not always coincide with the assumptions incorporated into the CEC forecast, the local forecast includes some adjustments to the CEC approach. Appendix E contains a more complete description of the assumptions, calculations, and adjustments employed in determining future local consumption patterns.

As with current consumption, future energy consumption patterns will vary from sector to sector. The factors which will shape consumption in each sector are discussed below.

RESIDENTIAL

Future residential consumption will be influenced by population growth, the number and type of dwelling units constructed, the increase in the number and types of appliances purchased by occupants of new and existing

homes, and the replacement of older, less efficient appliances with newer more efficient appliances.

Figure XII shows the projected gas and electricity consumption in 1985 and 1990 for the residential sector. The projections are based on an assumed population increase of slightly less than 1% per year over the next decade. The associated number and type of dwelling units are based on the zoning conditions contained in the Land Use Element for the County Comprehensive Plan.

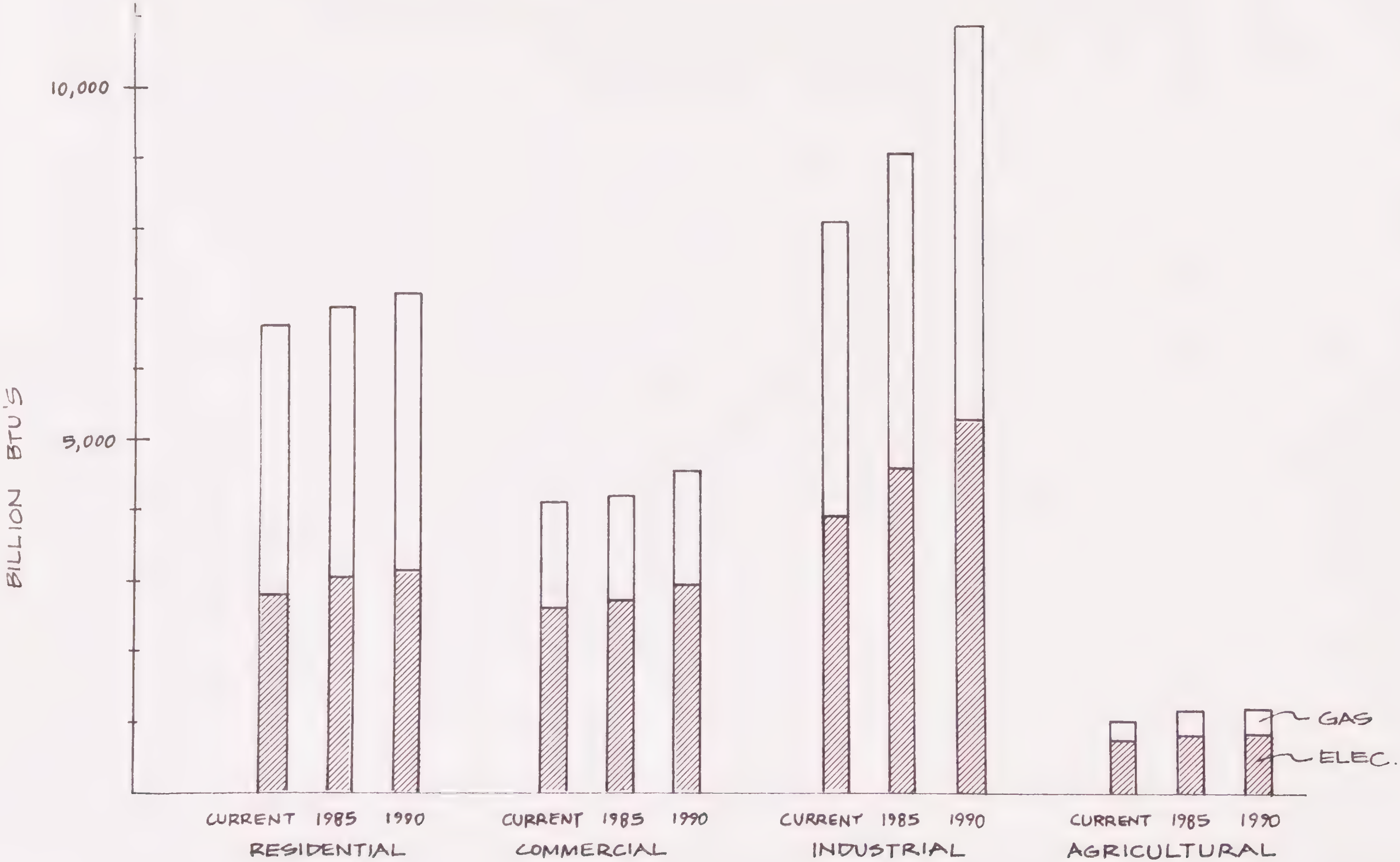
Two major state conservation programs are included in the residential forecast: Title 24 residential building standards and the appliance efficiency standards. The building standards will affect all new construction. The appliance efficiency standards will apply to all new appliances purchased for use in new homes and to replace appliances in the current stock of dwelling units. Although it is difficult to assess the energy consumption effects of the two adopted local solar ordinances, an estimate is incorporated into the forecast.

Not included in the residential forecast are the reductions in consumption resulting from a number of voluntary programs. The CEC and utility retrofit conservation programs, state and federal tax credits for conservation and solar energy equipment, and voluntary reductions in energy use because of increased energy costs can all be expected to result in additional reductions in conventional energy use. The reason for excluding the effects of these voluntary measures and incentives in the residential forecast is founded in the previous discussions of the obstacles and constraints characteristic of most voluntary programs. In effect, the residential forecast shown in Figure XII includes the assumption that reductions in conventional energy use will result primarily from existing mandated measures. Voluntary programs, it is assumed, will be constrained by a variety of perceptual, institutional, and economic considerations.

COMMERCIAL

Future energy consumption in the commercial sector is more difficult to project than the residential sector. To some extent, the difficulty is due to the limitations of information on existing consumption (discussed in Part I). Additionally, commercial sector consumption is only partially

FIGURE XII
PROJECTED ENERGY CONSUMPTION
CASE I



attributable to population growth and locally influenced land use decisions. Projected levels of personal income, changes in the types of commercial operations in the county, and the market orientation of these facilities will shape future commercial energy consumption, but are difficult to accurately project.

The projected commercial consumption (Figure XII) is based on the general assumption that future commercial energy needs in the county will follow the CEC projected commercial growth patterns for southern California. The CEC forecasted growth rate incorporates the effects of existing, mandated state and federal building and appliance efficiency standards for commercial operations.

INDUSTRIAL

Future industrial energy consumption will be influenced by the activities of the existing industries and the addition of new industrial facilities. As described in previous sections of this study, local industrial energy consumption is dominated by a few industries. Since the energy consumption of each industry will be affected by a wide range of future conditions shaped by factors outside the county, it is difficult to identify the future energy demands of existing industries.

A number of prospective industrial developments could dramatically increase the consumption of gas and electricity in the county. The following projects would significantly increase industrial energy consumption:

- the LNG facility at Point Conception
- a natural gas processing facility at Las Flores Canyon
- an additional refinery in the North County
- any significant increase in production of heavy oil in the North County
- the use of an onshore pipeline to transport oil from Santa Barbara Channel oil production
- industrial growth associated with expanded Vandenberg Air Force Base operations (i.e., the space shuttle program)

Each of the above industrial projects would entail a considerable increase in local industrial energy consumption, especially electricity. Moreover, if most of the large projects (LNG and the space shuttle program) do occur, the expected influx of construction workers could increase the local population and housing stock enough to affect residential sector projections.

Reductions in industrial sector energy consumption would result from utility and federal government industrial energy conservation programs and/or the use of cogeneration equipment in the North County oil fields. These possibilities are too speculative to incorporate into any forecast.

Because of the sensitivity of future local industrial consumption to many factors outside of the county, projected industrial consumption is based on the assumption that local growth will resemble state-wide industrial growth in consumption. The industrial sector forecast for the county (Figure XII) is based on this assumption.

AGRICULTURE

The central feature shaping agricultural energy consumption will be electricity for pumping irrigation water. The state and utility pumping efficiency programs can be expected to reduce consumption, but growth in demand would occur with any significant increase in water-intensive agricultural production. The future condition of the water table throughout the county will also affect pumping/electricity requirements; a lower water table would probably increase the amount of electricity necessary to pump the water from ground wells. The availability and costs of future water supplies will shape future levels of agricultural production, yet the costs of pumping or transporting water could alter the economics of different types of agricultural operations.

As with the industrial sector, future agricultural sector consumption will be heavily influenced by out-of-county developments which shape the production of agricultural goods. The forecast for local agricultural energy consumption (see Figure XII)therefore, assumes that local growth resembles the energy consumption growth rates for California agricultural sector energy consumption.

SUMMARY

Under the conditions and assumptions outlined above, future consumption in the county can be expected to increase slowly over the next decade. The forecast reflects the more recent statewide trend toward a slower growth rate in the consumption of natural gas and electricity. The major factors contributing to the slowed growth are reduced consumption with rising energy costs and the adoption of state and federal programs to reduce the consumption of conventional energy supplies.

As with any forecast, the projected energy consumption levels cannot be considered a <u>prediction</u>. The validity of a forecast is dependent upon the acceptance of a number of assumptions about future developments. Different assumptions would result in a different forecast. Among the most important assumptions used in the forecast are the relatively slow growth in population, and minimal new industrial growth. An assumption that most or many of the prospective industrial projects do materialize, and that these developments will bring a significant increase in population, would produce a forecast of significant but largely undeterminable increases in local energy consumption.

Alternatively, a forecast of local energy consumption could be based on the assumption that the county adopts an aggressive program to maximize the energy conservation and renewable resource potentials. As discussed throughout Part II, this potential is significant and has served to prompt state, federal and local agencies to adopt conservation/renewable resource programs. To the extent possible, the effects of these existing programs have been incorporated into the forecast of local energy consumption. Part III suggests the ways in which the county could play an assertive role in reducing the use of conventional energy resources, and identifies the effects of these programs on future energy consumption.

ENERGY CONSERVATION OPTIONS FOR SANTA BARBARA COUNTY

There exists a wide range of energy conservation options available to both individuals and to local goverment decision-makers, throughout the country, many communities have implemented various conservation strategies ranging from public information programs to encouraging voluntary measures to mandating local conservation ordinances.

Residents of the county currently have access to a number of conservation options. Local business offices of the various public utilities have instituted programs to encourage conservation. The county,through the Divsion of Building and Safety maintains a broad range of information on solar and conservation measures for new and existing building.

At the present time, the county has mandated three energy related measures. In 1977, the county enacted a water conservation ordinance which not only conserves water but reduces the energy needed to supply and dispose of water. Two solar ordinances were enacted in 1979, the first one requires solar heating on new swimming pools, the second ordinance requires solar domestic water heating in areas not served by natural gas.

Any further coordinated energy strategy or plan must respond to the following questions:

1) Will the measure apply to new buildings, existing buildings or both?
2) Which sectors (residential, commercial/government, industrial, agricultural) will the measure affect?
3) Will the measure require mandating, or can its ends be accomplished by voluntary compliance?

An energy conservation action program can be developed which utilizes a combination of goals and strategies. Changes in energy prices and public attitudes must be part of the considerations of policy-makers giving support to specific conservation strategies. "Benefit to cost ratios" must be utilized to determine the viability of and timing for any specific conservation measure.

The following options offer the greatest conservation potentials which can be implemented through individual and community iniative:

1. Encourage the incorporation of energy conservation measures in all existing buildings. This would include, but is not limited to:
   - installation of insulation where feasible
   - installation of plumbing flow restrictors
   - reduced operating hours for heating, ventilating and air conditioning systems.
   - installation of weatherstripping on all openable doors and windows
   - development of energy audit and energy management programs
   - implementation of operation and maintenance programs which contribute to energy conservation
2. Provide protection for solar access to insure that new construction does not shadow areas of adjacent property which are/to be utilized for solar collection.
3. Encourage the use of solar water heating on both existing and new construction.
4. Encourage the use of passive solar techniques for space conditioning in new construction.
5. Incorporate "energy impact assessments" as part of the EIR process on non-residential construction.
6. Promote the use of energy conserving landscaping. Such landscaping can reduce water (and associated) energy use, reduce building heat loss by acting as a windbreak, and reduce cooling loads by providing summer shade.
7. Develop public information programs on energy conservation and the use of renewable energy sources.
8. Expand county programs utilizing energy conservation and renewable resources recovery program.

9. Fxpand the county resource recovery program.
10. Conduct a feasibility study of methane gas recovery from the Tajiguas landfill.
11. Develop a uniform "life cycle cost" method to assess the benefit-cost ratic of any proposed conservation measure.

APPENDIX A

CURRENT ENERGY SUPPLY AND CONSUMPTION

Natural gas and electricity are supplied to Santa Barbara County through three major utility systems; Southern California Edison, Pacific Gas and Electric, and Southern California Gas. Table I shows the major supply characteristics of the three utilities.

Table I

UTILITY SUPPLY CHARACTERISTICS (1977)

Power Generation Sources	SCE		PG&E	
	kWh (millions)	%	kWh (millions)	%
Oil	35,702	56	21,149	32
Gas	9,219	15	22,344	34
Coal	8,642	14	-	-
Hydro	1,509	2	6,049	9
Nuclear	1,855	3	negl.	
Geothermal	negl.		3,582	6
Purchased Power	6,418	10	12,046	18
TOTAL	63,345	100	65,428	100

Southern California Gas (1977)		
Sources	MMCF	%
S. West US	742,410	96
California	18,980	2.5
Canada	7,665	1
Fed. OCS	3,285	.5
TOTAL	772,285	100

Source: Selected Energy Statistics, CPUC, 1978

Table II shows the breakdown of natural gas and electricity consumption in the unincorporated area of the county, excluding consumption at Vandenberg Air Force Base (VAFB). The consumption figures are based on utility sales information provided either directly to the county, or as reported to the CEC and the CPUC. Except for residential and industrial gas consumption, the figures in Table II are 1978 sales by the utilities. Because residential gas consumption is so dependent on climatic conditions, the average of 1977 and 1978 residential gas sales (excluding VAFB residential consumption) were used. As explained later, industrial gas consumption includes sales by SCG to industrial consumers, as reported to the Air Pollution Control District (APCD).

Table II

CURRENT ENERGY CONSUMPTION

	Natural Gas		Electricity		TOTALS			
SECTOR	MMCF	Billion BTU's	Million kWh	Billion BTU's	Billion BTU's	% gas	% elec	% of Total
Res.	3500	3800	270	2800	6600	58	42	33
Comm.	1400	1500	250	2600	4100	38	63	21
Ind.	3850	4150	370	3900	8050	52	48	41
Ag.	270	290	72	750	1040	28	72	5
TOTAL	9000	9700	960	10100	19800	49	51	100

The definition of non-residential sectors is based on the Standard Industrial Classification (SIC) code system. The SIC codes are used by a number of government agencies for data collection purposes. Since the utilities collect and report sales information to the CEC using SIC codes, the SCI information can be very helpful in establishing consistent definitions for each sector and disaggregating the information into categories within each sector. The use of SIC information for energy planning purposes is explained in subsequent discussions of energy consumption in each sector.

Tables III and IV show the estimates of how much gas and electricity were used for a variety of different residential uses. Table IV, the most detailed of the two breakdowns, is the basic source of residential

Table III

CURRENT RESIDENTIAL USES OF GAS AND ELECTRICITY

(Therms & kWh)

	NATURAL GAS				ELECTRICITY			
	S-F	M-F	Total (10^6)	% of Gas	S-F	M-F	Total (10^6)	% of elec
SPACE HEATING	17.9	3.85	21.70	57%	3.7	.6	13.4	5%
SPACE COOLING	.25	.06	.31	1%	2.26	1.12	3.38	1%
WATER HEATING	9.63	2.49	12.12	32%	11.1	18.1	29.1	11%
Basic	(7.46)	(2.3)	(9.76)		(9.1)	(16.4)	(25.5)	
Dishwasher	(1.44)	(.1)	(.54)		(.6)	(.8)	(1.4)	
Wash. machine	(1.03)	(.09)	(1.12)		(1.3)	(.9)	(2.2)	
Swimming Pool	(.7)	-	(.7)	-	-	-	-	-
Cooking	1.8	.62	2.42	6%	7.3	4.6	11.9	4%
Clothes Dryer	.64	.07	.71	2%	9.4	2.7	12.1	4%
Refrigerator	-	-	-	-	57.4	22.3	74.7	30%
Freezer	-	-	-	-	11.3	1	12.3	5%
Dish. Motor	-	-	-	-	4.6	1.4	6	2%
Wash Mach Motor	-	-	-	-	2.1	.3	2.4	1%
Television	-	-	-	-	8.1	3.7	11.9	4%
Lighting, Misc.	-	-	-	-	65.2	16.7	81.9	30%
Other	-	-	.7	2%	-	-	4.3	2%
TOTALS:	30.2	7.10	38.00	100%	181.8	80.4	268.00	100%

SF = Single Family

MF = Multiple Family

Table IV

END USE PATTERNS IN SINGLE AND MULTI-FAMILY DWELLING UNITS

(Therms & kWh)

	NATURAL GAS				ELECTRICITY			
	Sat. Lev. %	# of Appl.	UEC/yr (Therms)	Energy Consum (10^3)	Sat. Lev.	# of Appl.	UEC/Yr (kWh)	Energy Consum (10^3)
SINGLE FAMILY (31,070 Units)								
Space Heating	96	29,827	600	17,900	2	621	6,000	3,700
Space Cooling	4	1,243	200	250	6	1,864	1,214	2,260
Water Heating	-	-	-	-	-	-	-	-
Basic	92	28,585	26	7,460	6	1,864	4,876	9,100
Dishwasher	46	14,292	31	440	3	932	660	620
Washing Machine	84	26,410	39	1,030	5	1,554	841	1,310
Swimming Pool	4	1,243	579	720	-	-	-	-
Cooking	68	21,128	85	1,800	30	9,321	778	7,250
Clothes Dryer	49	15,224	42	640	25	7,768	1,212	9,410
Refrigerator	-	-	-	-	122	37,905	1,515	57,430
Freezer	-	-	-	-	28	8,700	1,294	11,260
Television (color)	-	-	-	-	87	27,031	300	8,110
Dishwasher Motor	-	-	-	-	49	15,224	305	4,640
Washing Machine Motor	-	-	-	-	90	27,963	76	2,130
Lighting, Miscellaneous	-	-	-	-	100	31,070	2,098	65,190
TOTAL (S-F)	-	-	-	30,200	-	-	-	182,000

(Continued Next Page)

TABLE IV (Con't)

MULTI-FAMILY (16,159 Units)	NATURAL GAS Sat. Lev.	# of Appl.	UEC/YR (Therms)	Energy Consum (10^3)	ELECTRICITY Sat. Lev.	# of Appl.	UEC/YR (Kwh)	Energy Consum (10^3)
Space Heating	68	10,988	350	3,850	30	4,848	2,000	9,700
Space Cooling	3	485	125	60	9	1,454	772	1,120
Water Heating	-	-	-	-	-	-	-	-
Basic	70	11,311	202	2,300	28	4,525	3,636	16,400
Dishwasher	31	5,009	20	100	12	1,939	435	840
Washing Machine	22	3,555	26	100	10	1,616	554	900
Cooking	55	8,887	70	620	43	6,948	667	4,600
Clothes Dryer	16	2,585	28	70	20	3,393	779	2,700
Refrigerator	-	-	-	-	101	16,321	1,366	22,290
Freezer	-	-	-	-	5	808	1,294	1,050
Television (color)	-	-	-	-	77	12,442	300	3,700
Dishwasher Motor	-	-	-	-	44	7,110	201	1,430
Washing Machine Motor	-	-	-	-	32	5,171	50	260
Lighting, Misc.	-	-	-	-	100	16,159	1,032	16,680
TOTAL (M-F)				7,100				81,700
TOTAL (S-F & M-F)				37,300				263,700
Other				700				4,300
TOTALS:				38,000				268,000

end use consumption estimates. In order to disaggregate residential consumption into dwelling unit and end use categories, it was necessary to determine the number of energy consuming appliances which are currently being used in single family and multi-family dwelling units and the amount of energy each appliance uses each year. "Saturation Level" refers to the percentage of households using the appliance associated with each end use. The "# of appliances" were derived by multiplying the saturation level percentages times the number of single family and multi-family dwelling units in the unincorporated area of the county. The estimated 31,070 single family and 16,159 multi-family houses are based on dwelling unit data provided by the County Planning Department. "UEC/yr.," unit energy consumption per year, refers to the average amount of energy consumed by each individual appliance. "Energy Consumption" is the total amount of energy consumed by all such appliances ("# of appliances" X "UEC/yr" = energy consumption).

Saturation levels and UEC estimates are, with one exception, taken from data supplied by the Assessments Division of the CEC. The exception concerns the UEC estimates for single family and multi-family space heating (gas and electric); CEC estimates are slightly lower than those shown in Table IV. The reason for increasing the UEC estimates for space heating is twofold: First, the CEC estimates do not distinguish between homes in the unincorporated and incorporated areas - since the Energy Element concerns unincorporated households, and homes tend to be larger in the suburban areas, the UEC is likely to be larger than the CEC estimate. Secondly, the UEC estimates from the Energy Commission were for an area which included only the southern portion of the county. Because the North County experiences slightly colder winters, space heating consumption will be greater, and the county average higher. Climate does not generally affect the other major end uses nearly as much as space heating.

The saturation levels and UEC estimates from the CEC were compared with spot surveys done by the local offices of the utilities. Although the categories were not always the same, the estimates in Table IV generally concur with utility survey information.

The category "Other" at the bottom of Table IV is simply the difference between the total consumption of all end uses and the utility sales in

the residential sector. The unaccounted for consumption ("Other") is primarily consumption of mobile homes and small appliances in all dwelling units. In the case of "Other" electricity, a significant portion could be accounted for by the use of electric fans for gas furnaces, swimming pool filter pumps, and electric room air conditioners. Estimates on saturation levels and UEC's for these uses are available, but the consumption generally was not large enough to warrant inclusion in the table.

Table V summarizes the residential end use consumption patterns in terms of British Thermal Units (BTU's).

TABLE V

MAJOR END USES IN ALL DWELLING UNITS

GAS AND ELECTRICITY

(billion BTUs)

	NATURAL GAS BTUs (10^9)	ELECTRICITY BTUs (10^9)	TOTALS			% of Residtl.
			BTUs	% gas	% ele.	
SPACE HEATING	2170	141	2311	94	6	35%
SPACE COOLING	31	35	66	47	53	1%
HOT WATER (all uses)	1212	287	1499	81	19	23%
CLOTHES DRYER	71	127	198	36	64	3%
COOKING	241	125	366	66	34	5%
REF. & FREEZ.	-	966	966	-	100	15%
TV	-	125	125	-	100	2%
LIGHTING, MISC.	-	860	860	-	100	13%
OTHER	70	128	200	36	64	3%
TOTAL	3800	2814	6614	57	143	100%

Tables VI and VII show energy consumption in the commercial sector. Based on Standard Industrial Classification (SIC) codes, commercial includes all businesses with SIC codes 40-96. The SIC "short titles" for these businesses are as follows:

40 Railroad Transportation
41 Local and Inter-urban Passenger Transit
42 Trucking and Warehousing
43 U.S. Postal Service
44 Water Transportation
45 Transportation by Air
46 Pipelines, except Natural Gas
47 Transportation Services
48 Communication
49 Electric, Gas, and Sanitary Services
50 Wholesale Trade - Durable Goods
51 Wholesale Trade - Nondurable Goods
52 Building Materials and Garden Supplies
53 General Merchandising Stores
54 Food Stores
55 Automotive Dealers and Service Stations
56 Apparel and Accessory Stores
57 Furniture and Home Furnishings
58 Eating and Drinking Places
59 Miscellaneous Retail
60 Banking
61 Credit Agencies
62 Security, Commodity Brokers and Services
63 Insurance Carriers
64 Insurance Agents
65 Real Estate
66 Combined Real Estate, Insurance, Etc.
67 Holding and other Investment Offices
70 Hotels and other Lodging Places
72 Personal Services
73 Business Services
75 Auto Repair, Services and Garages
76 Miscellaneous Repair Services
78 Motion Pictures
79 Amusement and Recreation Services
80 Health Services
81 Legal Services
82 Educational Services
83 Social Services
84 Museums, Botanical, Zoological Gardens
86 Membership Organizations
88 Private Households
89 Miscellaneous Services
91-97 Public Administration

Sic 91-97, government operations, is frequently treated as a separate category. Except for Sic 97, which is primarily Vandenberg Air Force Base, energy consumption in local government operations is not large enough to warrant separate treatment. Since energy consumption at the Base is not included in the study, the remaining governmental consumption patterns are considered typical of certain commercial operations ("offices" in Table VI).

Table VI

COMMERCIAL SECTOR CONSUMPTION, GAS AND ELECTRICITY

Building Type	SIC Code(s)	Natural Gas				TOTALS			
		MMCF	Bill BTUs	Mill BTUs	Bill BTUs	Bill BTUs	% gas	% elec	% of Sector
Offices	65;60-64;66; 67;73;81-83; 86;89;91-96.	146.7	158	32.4	340	498	32	68	12
Restaurant	58	205.0	220	18.0	189	409	54	46	10
Retail	52;53;56;57; 59;72;76.	173.4	186	24.7	259	445	42	58	11
Grocery	54	313.2	337	23.2	243	580	58	42	14
Warehouse	42; 50; 51.	25.6	28	10.1	106	134	21	79	3
Schools	82	275.0	296	70.0	735	1031	28	72	25
Health	80	56.1	60	8.2	86	146	41	59	4
Hotel/Motel	70	56.0	60	13.0	136	196	31	69	5
Other	40-41;43-49; 78-79;84;88	140.0	150	52.0	546	696	22	78	17
TOTALS:	40-96	1400.0	1505	250.0	2625	4150	36	64	100

The CEC disaggregates commercial energy consumption into building types which share similar energy consumption characteristics. In general, the building type and SIC groups associated with each type shown in Table VI are those used by the CEC. In a few cases, the CEC building type categories incorporate a more complete disaggregation and arrangement of SIC code groups. For example, CEC building types distinguish between elementary/secondary schools and colleges/universities. In order to make this distinction, it is necessary to break out the two digit group "Educational Services" (SIC 82) into three digit sub-categories (SIC 821 for elementary/secondary schools, and 822 for colleges/universities). Since three digit SIC code energy consumption was not made available to the county, it was not possible to exactly duplicate the CEC approach.

The "other" category in Table VI includes commercial SIC code operations which are not readily characterized by typical energy consumption patterns Of the SIC codes in the "other" group, code 49 (Electric, Gas and Sanitary Services) is the dominant one in terms of energy consumption (especially electricity). It was not possible to accurately determine the subcategories or end uses of SIC 49 energy consumption, a portion of which may be typical of other building types.

The most accurate approach to commercial end use consumption is to establish the square footage of all building types. With square footage estimates it is possible to use BTU (gas and electric equivalent) consumption for each end use and each building type. Square footage and consumption figures are available from CEC, but are based on aggregate figures for each electric utility service area. The CEC estimates of square footage are based on actual building data purchased by the CEC from the FW Dodge Co. in San Francisco. The Dodge figures are disaggregated by county, but county specific data must be purchased directly from the company. Since no other source of commercial square footage estimates was available, it was not possible to duplicate all aspects of the CEC commercial end use consumption patterns. The approach used to establish the end use consumption shown in Tables VII and VIII, therefore, include CEC estimates derived from the primary data from the Dodge Company and county specific consumption figures supplied by the utilities. Electricity consumption, Table VII, is based on SIC sales data provided by PG&E and SCE. In the case of PG&E, sales by two digit

TABLE VII Commercial Electricity End Uses
(thousand kwh)

Building Type	Sp. Heat %	Sp. Heat kwh	Air Cond. %	Air Cond. kwh	Ventilat. %	Ventilat. kwh	Wat. Heat %	Wat. Heat kwh	Cooking %	Cooking kwh	Refrig. %	Refrig. kwh	Lighting %	Lighting kwh	Misc. %	Misc. kwh	TOTAL kwh
Offices	.018	583	.423	13705	.105	3402	.01	324	.002	65	.003	97	.433	14029	.006	194	32,400
Restaurants	.156	2808	.232	4176	.135	2430	.012	216	.014	252	.069	1242	.377	6786	.003	54	18,000
Retail	.052	1284	.371	9164	.084	1512	.009	222	.002	49	.031	766	.444	10967	.006	148	24,700
Grocery	.024	556	.032	741	.057	1320	.001	23	.001	23	.564	13057	.319	7385	.001	23	23,150
Warehouse	.095	960	.110	1111	.015	152	.001	10	--	--	.09	910	.662	6686	.026	263	10,100
Schools	.012	840	.125	8750	.058	4060	.063	4410	.001	70	.015	1050	.720	50400	.006	420	70,000
Health	.010	82	.297	2435	.122	1000	.056	459	.001	8	.019	156	.471	3862	.025	205	8,200
Hotel/Motel	.018	234	.516	6708	.179	2327	.013	169	.004	52	.014	182	.250	3250	.006	78	13,000
Other	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	50,000
TOTAL	.03	7347	.19	46790	.06	16203	.02	5833	negl.	519	.07	17460	.41	103365	.01	1385	250,000

TABLE VIII Commercial Natural Gas End Uses
(million cubic feet)

Building Type	SP. Heat %	SP. Heat MMCF	Air Cond. %	Air Cond. MMCF	Wat. Heat %	Wat. Heat MMCF	Cooking %	Cooking MMCF	Refrig. %	Refrig. MMCF	Misc. %	Misc. MMCF	TOTAL MMCF
Offices	.477	70.8	.258	37.8	.052	7.6	.005	.7	.001	.2	.206	30.2	146.4
Restaurants	.763	156.4	.025	5.1	.154	31.6	.025	5.1	.002	.4	.032	6.6	205.0
Retail	.378	65.6	.130	22.5	.016	2.8	.003	.5	.016	2.8	.457	79.2	173.4
Grocery	.987	309.1	.001	.3	.009	2.8	.001	.3	--	--	--	--	313.2
Warehouse	.673	17.2	.248	6.3	.011	.3	.002	.1	.068	1.7	--	--	25.6
Schools	.401	110.3	.128	35.2	.099	27.2	.013	3.6	.007	1.9	.363	99.8	275.0
Health	.221	12.4	.296	16.6	.372	20.9	.028	1.6	.008	4.9	.088	4.9	56.1
Hotel/Motel	.173	9.7	.070	3.9	.108	6.1	.006	.3	--	--	.621	34.8	56.0
Other	--	--	--	--	--	--	--	--	--	--	--	--	140.0
TOTAL	.54	751.1	.09	127.7	.07	99.3	.01	12.2	.01	11.9	.18	255.5	1400.0

level SIC customers in the unincorporated area of the county were provided. For North County commercial electricity consumption, therefore, comparatively accurate information was available. The local office of SCE was able to provide aggregate sales for non-residential customers in the unincorporated area, but a SIC breakdown was provided for sales in the Santa Barbara district as a whole (incorporated and unincorporated areas). In order to match the aggregate sector sales in the unincorporated area to the SIC information, it was necessary to estimate the percent of each major SIC category which was consumed in commercial operations located in the unincorporated area only. After consultation with SCE officials familiar with the location and consumption levels of local customers, it was possible to estimate consumption by SIC code in the unincorporated area.

The end use consumption of electricity in the commercial sector shown in Table VII is based on estimates by the CEC. The CEC forecasting model includes an estimate of the percent of electricity consumed by each building type for each end use. The "%" column in Table VII uses the figures provided by the CEC for commercial electrical consumption in the SCE service area.

Data on commercial sector natural gas consumption, Table VIII, suffers from greater limitations. Southern California Gas did not provide SIC sales figures for commercial customers in the Santa Barbara area. The only figuresmade available by the local SCG office were aggregate commercial sector sales in the unincorporated area. In order to disaggregate commercial gas consumption into the SIC-based building types, it was necessary to estimate the percent of commercial sector gas consumed by each building type. The CEC estimates for commercial gas use are: Offices (.149); Restaurants (.208); Retail (.176); Grocery (.138); Warehouses (.026); Schools (elementary/secondary and colleges combined, .176); Hospitals (.057); Hotel/Motel (.056); and Misc. (.065). These percentages, based on SCE service area commercial gas consumption patterns, were assumed to be typical of Santa Barbara County commercial gas consumption, with one exception. Consumption at the University of California, Santa Barbara, approximately 230,000 MCF/yr. is large enough to warrant adjustment of the percentages provided by the CEC.

The adjustment was made as follows: excluding VAFB and "other" (estimated to be 10% of commercial gas consumption), total commercial gas consumption is about 1,260 MMCF: the estimate for building type "Schools" (including, but not limited to, UCSB) is approximately 275 MMCF/YR. leaving slightly less than 1,000 MMCF consumed by other building types; if it is assumed that the gas consumption patterns for the remaining building types resemble consumption elsewhere in southern California, the 1,000 MMCF (non-schools and non-"other") commercial sector consumption can be disaggregated according to the building type by using the CEC percentages listed above. The "total consumption" column for each building type in Table VIII is the result. The breakdown by end use incorporates the CEC estimates for each building type and each end use, as with electricity.

TABLE IX Summarizes Commercial Sector Consumption.

TABLE IX

Commercial End Uses, All Building Types

END USE	Natural Gas		Electricity		TOTALS			
	MMCF	BTU (10^9)	Million kWh	BTU (10^9)	BTU (10^9)	% Gas	% Elect.	% of sector
Space Heat	751.1	807	7.4	78	885	91	9	21
Air Cond.	127.7	137	46.8	491	628	22	78	15
Ventilat.	-	-	16.2	170	170	0	100	4
Water Heat	99.3	107	5.8	61	168	64	36	4
Cooking	12.2	13	.5	5	18	72	18	negl.
Refrig.	11.9	13	17.5	184	197	7	93	5
Lighting	-	-	103.4	1086	1086	0	100	26
Misc.&Other	395	425	51.3	539	964	44	56	23
TOTAL	1400	1500	250	2600	4100	37	63	100

Table X shows the SIC breakdown of consumption in the industrial sector. A description of the major industrial categories listed in the table is as follows:

13 OIL AND GAS EXTRACTION (crude Petroleum & Natural Gas; Natural Gas Liquids; Oil & Gas Field Services; Drilling Oil & Gas Wells; Oil & Gas Exploration)

20 FOOD AND KINDRED PRODUCTS (Meat Products; Dairy Products; Preserved Products; Preserved Fruits and Vegetables; Grain Mill Products; Bakery Products; Sugar and Confectionery Products; Fats and Oils; Beverages; and Miscellaneous)

29 PETROLEUM AND COAL PRODUCTS (Petroleum Refining; Paving and Roofing Materials, and Miscellaneous)

32 STONE, CLAY AND GLASS PRODUCTS (Flat Glass; Glass and Glassware; Structural Clay Products; Pottery and Related Products; Concrete, Gypsum, and Plaster Products; Cut Stone and Stone Products; and Miscellaneous)

33 PRIMARY METALS (Blast Furnaces and Basic Steel Production; Iron and Steel Furnaces; Primary and SEcondary Nonferrous Metals; Nonferrous Foundaries)

36 ELECTRIC AND ELECTRONIC EQUIPMENT (Electric Distributing Equipment; Household Appliances; Electric Lighting and Wiring; Radio and TV Receiving Equipment; Communication Equipment; Electronic Components; and Miscellaneous)

38 INSTRUMENTS AND RELATED PRODUCTS (Engineering and Scientific Equipment; Measuring and Controlling Devices; Optical Instruments and Supplies; Medical Instruments; Photographic Equipment)

TABLE X Industrial Energy Consumption

	Natural Gas		Electricity		TOTALS			
SIC CODE	MMCF	Billion BTUs	Million kWh	Billion BTUs	Billion BTUs	% gas	% elect.	% of sector
13	--	--	60.5	635	635	-	100	8
20	1000	1075	19.5	205	1280	84	16	16
29	430	460	160	1680	2140	21	79	27
32	2080	2240	86	900	3140	71	29	39
33	--	--	10.4	110	110	-	100	1
36	--	--	10.0	105	105	-	100	1
38	--	--	15.0	160	160	-	100	2
Other	350	375	10.0	105	480	78	22	6
TOTAL	3850	4150	370	3900	4150	52	48	100

Industrial sector consumption figures can be considered relatively accurate. Electricity consumption is based on PG&E-supplied two digit SIC information in the unincorporated area and the SCE-supplied SIC breakdown, adjusted for customers in the unincorporated area (as described in the preceding discussion of commercial electrical consumption). In the case of electricity consumption in SIC 20, the electricity generated at the Union Sugar cogeneration facility was added to PG&E sales to that category. Out of the 370 million kWh consumption shown in Table X, PG&E sales account for 270 million (73%).

Estimates of industrial natural gas consumption are difficult, not only because SCG did not provide SIC data, but because industrial gas use can vary significantly from year to year. To some extent, the annual fluctuations in industrial gas consumption are due to periodic gas curtailments to low priority customers, most of which are industrial. In the case of Santa Barbara, however, industrial sector gas consumption in recent years has been affected by an agreement between the local APCD and several large industrial gas users to determine the air quality effects of substituting (in part) natural gas with fuel oil. A second problem concerns the dramatic drop in gas (and fuel oil) use by the Union Sugar Company in recent years. The reduction in consumption was due primarily to the change from a good year for sugar in 1976 to a bad one in 1978.

In order to compensate for the limitations and problems associated with industrial gas use, and still establish a reasonable estimate of current industrial gas needs, it was necessary to piece together information from several sources. 1) The aggregate 1976 gas sales to industrial customers in the unincorporated area, as provided by SCG, was about 2,750 MMCF; 2) According to a CPUC report dated October 19, 1977, gas sales to industrial customers in the unincorporated area of the county subjected to curtailment (but not necessarily curtailed), amounted to 2,400 MMCF. It is assumed that the difference between the 2,700 (sold to interruptible customers) was to "firm" industrial customers. This difference, 350 MMCF, constitutes the "other" category in Table X, and corresponds to the "General Service" category of sales reported in the

SCG aggregate industrial sales information for 1976; 3) In order to allocate the 2,400 MMCF to specific industrial uses by SIC code, the CPUC report, which included a four digit SIC code breakdown, was used. According to that report, 1976 sales by SIC code were:

2063	(Union Sugar	760 MMCF
2911	(Douglas Refinery)	387 MMCF
3295	(Johns-Manville)	786 MMCF
3295	(Grefco)	431 MMCF

An additional 42 MMCF was reported sold to SIC 2951 ("Paving Mixtures"), producing a total of 2,400 MMCF, as mentioned above. According to APCD records, two of the industries, Union and Johns-Manville, reported the use of fuel oil in 1976. Union used about 120,000 barrels of fuel oil, the equivalent of about 700 MMCF, in 1976, and J-M about 110,000 barrels of distillate or 600 MMCF equivalent.

Douglas and Grefco reported no use of fuel oil in 1976, meaning the quantity or quality of fuel oil use did not require submittal to the APCD. Total 1976 gas and fuel oil equivalent industrial consumption, therefore, was the sum of Union Sugar gas and fuel oil (1,460 MMCF), J-M gas and fuel oil equivalent (1,390 MMCF), Douglas, Grefco, and "Paving Mixtures:" gas (860), and "other," non-interruptable gas (350). Total gas consumption, according to these sources, was the equivalent of about 4,100 MMCF in 1976; 4) Since the gas and fuel oil consumption of the two largest users, Union and J-M, has changed considerably in the last three years, 1976 cannot be considered the best estimate of current industrial gas demand in the county. Since Union and J-M gave reported gas and fuel oil consumption to the APCD for 1976-78, a three year average for these two industries can be used to establish a better estimate. According to APCD records, the three year average (combined gas and fuel oil equivalent for Union Sugar was about 1,000 MMCF and 1,650 MMCF for J-M. If it is assumed that the consumption of Douglas, Grefco, and "other" industrial gas customers has remained relatively constant for the last few years, a reasonable estimate of current gas demand (including a portion of fuel oil equivalent) can be determined. Industrial gas consumption figures in Table X are the three year average of Union and J-M and the 1976 consumption for the other categories; 5) As a final check on the accuracy of the gas figures in Table X, the three year average of <u>aggregate</u> sales

by SCG to industrial customers in the unincorporated area can be compared with the total sales in Table X, also a three year average, but derived through the process described above. As reported by SCG, the three year industrial sales (sector aggregate) were 2,750 MMCF in 1976, 3,412 in 1977 and 2,800 MMCF in 1978 for a three year average of almost 3,000 MMCF. Total sales in Table X, 3,860 MMCF, includes the fuel oil equivalent consumption by Union and J-M, about 45% and 12% respectively. If the fuel oil equivalent portion of the figures shown in Table X (SIC 20 and the J-M portion of SIC 32) is subtracted from the total, the total gas is about 3,000 MMCF, corresponding to SCG aggregate sales. In short, the 3,860 MMCF listed as total industrial gas consumption in Table X represents the consumption of 800-900 MMCF equivalent and 3,000 MMCF of purchased gas.

Not included in Table X is the natural gas consumed in conjunction with oil extraction operations. The estimated consumption of natural gas for the purpose of thermal injection (4.9 BCF/yr.) is based on the size and number of steam generator boilers used in the Cat Canyon oil field area, as reported by the County Petroleum Administrator. There are 37 gas burning units in the county rated at 871 million BTU/hr (total). Approximately 15% of this capacity is idle, a typical percentage. The remaining 736 MMBTU/hr units consume natural gas (from the field) at the rate of 18.2 MCF/MMBTU/day: 736 x 18.2 = 13,395 (MCF/day) x 365 (days) = 4,889,248 MCF/yr or 4.9 BCF/yr. In addition, field gas is used for heaters and natural gas engines and several oil fields burn fuel oil (at the rate of about 300 barrels/day) instead of natural gas for thermal injection purposes.

Agricultural consumption, Table XI, includes SIC categories 01 through 09. The categories within the major agricultural groupings are as follows

01 AGRICULTURAL PRODUCTION - CROPS (Cash Grains; Field Crops; Vegetables and Melons, Fruits and Tree Nuts; Horticultural Specialties; General Farms, Primarily Crop)

02 AGRICULTURAL PRODUCTION - LIVESTOCK (Livestock, Excluding Dairy; Poultry; Dairy Farms; Poultry and Eggs; Animal Specialties; General Farms, Primarily Livestock)

07 AGRICULTURAL SERVICES (Soil Preparation Services; Crop Services; Veterinary Services, Animal Services; Farm Labor and Management Services; Landscape and Horticultural Services)

TABLE XI

Agricultural Energy Consumption

SIC CODE	Natural Gas		Electricity		TOTALS			
	MMCF	Billion BTUs	Million kWh	Billion BTUs	Billion BTUs	% gas	% elect	% of sector
01	203	218	50.5	527	745	29	71	72
02	40	43	12	126	169	25	75	16
07	27	29	6.7	70	99	29	71	10
other	--	--	2.8	29	29	--	100	3
TOTAL	270	290	72	750	1040	28	72	100

As with the commercial and industrial consumption data, agricultural electricity consumption in Table XI is based on a combination of PG&E sales to customers in the unincorporated area (approximately 90% of the agriculture electricity) and SCE sales in the South Coast. Since SIC code figures provided by SCE included the incorporated areas of the South Coast, it was necessary to adjust the data to exclude those areas. Comparing local SCE office aggregate agricultural sales in the unincorporated area (7 million kWh), to the agricultural SIC sales (totaling 10.4 million kWh), approximately 67% of the reported SIC sales were to customers in the unincorporated area. The SCE portion of the electric consumption figures in Table XI include this adjustment.

The lack of SIC data for agricultural natural gas consumption makes it extremely difficult to estimate agricultural gas requirements. Aggregate agricultural sector (SIC 01-09) gas sales in 1978 for the entire county, as reported to the CEC, was about 540 MMCF. Since a major agricultural user of gas is the greenhouse industry, and since that industry includes a number of large operations in the City of Carpinteria, an arbitrary assumption wasmade that one-half of the 540 MMCF was for agricultural operations in the unincorporated area. The distribution of the 270 MMCF gas consumption into the three SIC divisions in Table XI is based on the arbitrary assumption that 75% is for SIC 01 (which includes greenhouses), 15% for SIC 02, and 10% for SIC 07.

Table XII combines the sector consumption figures in preceding tables into seven major end use categories. Except for agricultural space heatin (gas), space heating, space conditioning, water heating, refrigeration, and lighting figures were taken from the residential and commercial sector tables. The agricultural gas estimate is a very rough one, constituting most of agricultural SIC 01 from Table XI. Pumping and industrial process figures are very rough estimates, derived from Tables X and XI. The "other" category certainly includes small amounts of consumption for some of the specific end uses listed in Table XII, but lack of detailed end use information in the industrial and agricultural sectors precludes making any estimates.

Table XII

Combined End Use Consumption (Billion Btus)

	Nat. Gas	Electricity	Total
Space Heat	3170	220	3340
Space Cool	170	525	700
Hot Water	1300	350	1650
Ref. & Freezing	13	1150	1260
Lighting	-	2050	2050
Pumping	Negl	2600	2600
Indust. Processes	3775	1700	5475
Other	1300	1500	2800
Total	9700	10100	19800

Appendix B

ENERGY SAVING POTENTIALS OF ENERGY CONSERVATION MEASURES

Retrofit Attic Insulation: It is unknown just how many Santa Barbara County residences have adequate (R-19) attic insulation. Table I compares a number of estimates of the distribution of attic insulation R-values among residential buildings. The two Southern California Gas Company estimates are for gas-heated single family homes within its service area. The other estimate from the State Energy Commission is an average for single family dwellings throughout the State.

Table I

ESTIMATES OF EXISTING CEILING INSULATION LEVELS IN RESIDENCES

<table>
<tr><th>Survey Source</th><th>% Uninsulated</th><th>% Underinsulated</th><th>% R-19</th></tr>
<tr><td>Southern CA Gas[1]</td><td>31%</td><td>57%</td><td>12%</td></tr>
<tr><td>Southern CA Gas[2]</td><td colspan="2">54%</td><td>42%</td></tr>
<tr><td>Energy Commission[3]</td><td>42%</td><td>25%</td><td>33%</td></tr>
</table>

SOURCES: 1 Mr. Mike Neu, 7-79
2 Draft Air Quality Attainment Plan, 1978
3 1977 Biennial Report of the State Energy Commission, Vol. 3

For this study, the percentage distribution of estimate #1 has been assumed in calculations of potential County-wide energy savings. Also, it is assumed that this distribution holds for single family as well as multi-family gas heated housing stock. However, the percentage of apartment dwellings which can be retrofitted with attic insulation will be much less than the percentage of single family dwellings, because many apartment units have floors above, making retrofitting unfeasible. The Energy Commission has estimated that about 30% of apartment units statewide are suitable for retrofit attic insulation (Final EIR, Residential Insulation Program, 1978).

Estimates of ceiling insulation in electrically heated units indicate that for all practical purposes, these dwellings are insulated adequately. Therefore, this study assumes that no electrically heated units will be retrofit-insulated.

Table II shows estimates of the energy savings associated with retrofit attic insulation. Most of these estimates have been made for a 'typical' single family house. The Southern California Gas Company estimates 'typical' as an average of 20,000 gas-heated houses for which the Gas Company has arranged retrofit attic insulation to be installed. The Community Action Commission's typical house is an average of 180 good-condition, wood-constructed, gas-heated homes within Santa Barbara County which the Commission has retrofitted with attic insulation. The other estimates are made as average Southern California savings potentials.

Table II

ENERGY SAVINGS ESTIMATES FOR RETROFIT CEILING INSULATION

Estimate Source	Original Level of Ceiling Insulation	% of Heating Energy Saved
Southern CA Gas[1]	Uninsulated Underinsulated	20% 4%
Community Action Commission[2]	Uninsulated	32%
Lawrence Berkeley Lab.[3]	Uninsulated	33% (max)
CA Energy Commission	Uninsulated Underinsulated	30% 6%
Used for this Study	Uninsulated Underinsulated	20-33% (& 27% av) 3-10% (& 7% av)

SOURCES: 1 Mr. Roger Embry, 9-79
2 Ms. Heidi McCune, 9-79
3 "Preliminary Assessment of Energy Conservation Strategies and Measures," 10-76

This study assumes that multi-family dwellings will realize the same proportional energy savings as single family houses.

Weatherstripping: Table III shows an estimate of energy savings resulting from weatherstripping an existing dwelling:

Table III

ENERGY SAVINGS FOR WEATHER STRIPPING

Estimate Source	% of Heating Energy Saved
CA Energy Commission	6-8% (7% avg.)

SOURCE: The Natural Gas Study, 1978, Appendix B

Table IV shows an estimate of the percentage of units requiring weather-stripping:

Table IV

ESTIMATES OF DWELLING UNITS REQUIRING WEATHERSTRIPPING

Estimate Source	% of Units Requiring Weatherstripping
Southern CA Gas Co.[1] Assumed	48% of gas units 25% of electric units

SOURCE: [1]Mr. Mike Neu, SCGC, 9-79

Retrofit Insulation of Water Heaters: Southern California Gas Company makes the following estimate o. the potential market for retrofitting water heater insulation:

- % of all water heaters which are uninsulated and can be retrofitted: 60%
- % of all water heaters for which SCGC has sold a water heater insulation kit: 6%

Table V shows the energy saving estimates for retrofitting R-6 insulation on an average water heater tank:

Table V

ENERGY SAVINGS ESTIMATES FOR WATER HEATER TANK INSULATION

Estimate Source	Water Heating Energy Saved	
	Gas	Electric
CEC[1]	3%	4%
LBL[2]	6%	6%

SOURCES: 1 1977 Biennial Report, op. cit.
2 Op. cit., 10-76.

Plumbing Flow Restrictors: Table VI shows estimates of the energy savings resulting from installation of plumbing flow restrictors in shower heads:

Table VI

ENERGY SAVINGS ESTIMATES FOR USE OF SHOWER FLOW RESTRICTORS

Estimate Source	Water Heating Energy Saved
LBL[1]	7-15% (depends upon consumption rates)
Used for this study	10%

SOURCE: [1]Op. cit., 10-76

Lighting: Table VII shows the estimated energy savings potential of a number of lighting conservation measures for existing commercial buildings.

Table VII

ENERGY SAVINGS ESTIMATE FOR LIGHTING CONSERVATION MEASURES

Measure	Annual Energy Savings/Sq. Ft.
Reduce lighting levels in working areas by 1/3, by: (i.e., from 3.3 to 2.2 w/ft^2)	
De-lamping	3.2 kWh/ft^2
De-lamping w/ballast disconnection	3.3 kWh/ft^2
Replace tubes w/phantom tubes	3.5 kWh/ft^2
Daylight outer 20% of office space in building	3.3 kWh/ft^2
Turn off lights when all or part of building is not in use (manual or automatic)	0.66 kWh ft^2
Install lower wattage tubes and bulbs on next replacement cycle	0.69 kWh/ft^2
Task-oriented lighting	1.6 kWh/ft^2

COSTS OF ENERGY CONSERVATION MEASURES

Attic Insulation Retrofits: A survey of local retrofit attic insulation costs is shown in Table VIII.

Table VIII

LOCAL COST ESTIMATES FOR RETROFIT CEILING INSULATION

Estimate Source	For Uninsulated Dwelling Cost ($/sq ft)	For Underinsulated Dwelling
Southern CA Gas[1]	.35/ft^2	.25/ft^2
Sears[2]	.34/ft^2	not offered
Casa Insulation[3]	.30/ft^2	.15/ft^2

[1]Fiberglass or rock wool; SCG does arranging of contract with local insulating contractor

[2]Rock wool

[3]Rock wool

Weatherstripping: Contract installed weatherstripping of hinged exterior doors and wood framed windows will cost approximately the following:

Installed weatherstripping of one door - $30-$35

Installed weatherstripping of one window - $10-$15

SOURCE: Local survey of weatherstripping installers

Water Heater Tank Insulation: Do-it-yourself kits for R-6 water heater insulation are available locally for about $12.00/ea.

SOURCE: Local survey of hardware stores

Flow Restrictors: Flow restrictors cost anywhere from $.50 to $10.00, but most restrictors run an average of $1.50.

SOURCE: Local survey of plumbing supply stores

Appendix C

MUNICIPAL SOLID WASTE CONVERSION

Energy Potential

Santa Barbara County has not surveyed the composition of its own municipal solid waste (MSW) stream, although volume has been estimated. Waste stream composition data are based on national average MSW composition. This assumption was also used by the county in its solid waste management plan. The actual composition of county MSW is probably different. Table 1 shows the size and composition of the county waste stream for 1975, plus projections for 1980 and 1990. In all three cases, the percent composition of the waste stream is assumed to be constant.

Potential material recovery rates, estimated by the Environmental Protection Agency (EPA), are 65% for ferrous metals, 51% for aluminum, and 27% for paper (all types), using current recovery technologies. Table 2 shows material recovery potential and resultant energy savings for the county. Based on the EPA recovery rates, the county could reduce its waste stream volume by about 20% - 52,000 tons/year in 1980, and 69,000 tons/year by 1990 (assuming a 6-day week and 52-week year). Total energy savings would amount ot 168,000 barrels/year of oil by 1980 and 212 barrels/year in 1990. The amount of material currently recovered and estimated energy savings by the Santa Barbara County Resource Recovery Program and SUNRAE are shown in Table 3. According to Table 3, only 17% of potentiall recoverable material is being collected. This amounts to a 3% reduction in the total waste stream.

The EPA estimates that 70-80% of MSW is theoretically combustible, with a heating value of 9 million BTU/ton of MSW. Almost 4 billion BTU/day is currently being buried at county-operated landfills, based on the EPA factors and Table 1. Assuming that landfills operate 6 days/week and 52 weeks/year, this adds up to about 2 trillion BTU of <u>theoretically</u> recoverable energy annually. Not all this energy is realistically recoverable. Given the recovery efficiencies of current technologies, and the fact that not all waste is properly disposed (e.g., litter), EPA estimates that about 50-60% of MSW is potentially available for combustion. The "realistic" energy potential of MSW in the county is therefore approximately 1 trillion BTU/year, excluding conversion losses (waste heat and

Table 1

SIZE AND COMPOSITION OF MUNICIPAL WASTE STREAM IN COUNTY

Material	Quantity (tons per day) 1975	1980[1]	1990[2]	% of Total
Paper	288	311	367	33%
Glass	76	82	97	9%
Metals	-	-	-	-
Ferrous	70	76	90	8%
Aluminum	8	9	10	1%
Other Non-Ferrous	nil	nil	nil	-
Plastics	26	28	33	3%
Rubber and Leather	23	25	29	3%
Textiles	12	13	15	1%
Wood	31	33	40	4%
Food Wastes	138	149	177	16%
Yard Wastes	157	170	201	18%
Misc. Inorganics	38	41	49	4%
TOTALS:	867	937	1,108	100%

Source: Santa Barbara County, Solid Waste Management Plan, Final Draft, December, 1975.

1/ Based on population growth factor of 1.08 from 1975

2/ Based on population growth factor of 1.28 from 1975.

Table 2

POTENTIAL ENERGY SAVINGS FROM MATERIAL RECOVERY PROGRAMS

Material	Quantity Recovered (tons/day) 1980	1990	Energy Saved (Barrels of Oil) 1980	1990
Paper	78	99	312	396
Glass	39	49	9	11
Ferrous Metals	46	59	92	118
Aluminum	4	5	125	156
TOTALS:	167	212	538	681

*Energy Conversion Factors:

Paper: 4bbl/ton

Glass: .22 bbl/ton

Ferrous Metals: 2bbl/ton

Aluminum: 31.2 bbl/ton

Source: Santa Barbara County Solid Waste Management Plan and Chris Olson, Community Environmental Council

Table 3

ENERGY CONSERVATION THROUGH RESOURCE RECOVERY

OF RECYCLABLE MATERIALS

SANTA BARBARA COUNTY TOTALS

CENTERS SURVEYED: C.E.C., I.V. (S.U.N.R.A.E.), LOMPOC (S.A.V.E.), V.A.F.B. CENTER, SANTA MARIA.

	PRESENT (1977)		PROJECTED (1979)	
	Tons	Energy Saved In barrels of Crude Oil	Tons	Energy Saved In Barrels of Crude Oil
Paper	5,526	22,104	8,522	34,088
Aluminum	51	1,734	168	5,236
Glass	420	94	805	180
Ferrous Metal	21	42	91	184
TOTALS:	6,018	23,974	9,586	39,688

incomplete combustion). Table 4 gives the realistic energy potential in the county for 1975, 1980, and 1990. The amount of useful energy recoverable from MSW will be much lower than the potential amount, depending on the type of energy produced.

Methane Gas Recovery at Tajiguas

Tajiguas landfill is the most likely site for methane gas recovery, because it is the largest landfill site in the county. Tajiguas encompasses 412 acres, with a total capacity of 3.7 million tons of MSW. The current waste volume disposed at Tajiguas is 556 tons/day.

No study has been made of gas production potential from Tajiguas. Methane is currently being recovered from three California landfills - Palos Verdes and Sheldon-Arleta in Los Angeles County, and Shoreline Park in the City of Mountain View. The Tajiguas gas production estimates are based on the methodology and assumptions used at Mountain View, because data was more readily available than from the other sites. Waste volume and landfill depth however, are estimates for Tajiguas itself.

Total methane potential of landfilled MSW is 150 standard cubic feet/(scf) ton of waste. If Tajiguas were filled to its capacity, the total amount of raw (unprocessed) gas that could be produced would be:
Volume = 150 BTU/ton (3.7 million tons) = 555 million BTU. Not all this gas would be produced at once. Methane is produced over time, as anaerobic bacteria breakdown the organic portion of the buried refuse. Based on the experience at Mountain View and Palos Verdes, significant quantities of gas are not produced until the waste has been in place for 5-10 years. The gas production rate is dependent on the amount of organic material in the waste, moisture content, landfill depth, and temperature.

If uncontrolled, the methane can leak out through weak points in the landfill cover, creating an unpleasant odor, and a possible explosive. To control leakage, landfill operators routinely drill wells to bleed off the gas, which is then burned. With minor modifications, the leakage control well system can be designed to extract gas for use as an energy resource. The optimum well production rate has been found to be 1 scf/ft. of well depth. Daily methane production from a well field can be calculated as: Production (cubic ft./day, or cfd) = 181,106 $\left(\frac{AH}{R^2}\right)$

Table 4

ENERGY RECOVERY POTENTIAL FROM COUNTY MUNICIPAL WASTE

Year	Potentially Combustable Waste[1] (tons/year)	Recoverable Energy[2/] (Billions of Btu)
1975	148,777	1339
1980	160,789	1447
1990	190,132	1711

[1]Assumes 55% of waste is available for combusion

[2/]Assumes 9 million Btu/ton MSW

Table 5

ASSUMPTIONS FOR TAJIGUAS METHANE PRODUCTION

Variable Symbol	Variable Name	Value for Tajiguas
A	Well Field Area (acres)	50
H	Landfill Depth (feet)	150
R	Radius of Area Influenced By a Single Well (feet)	130
C	Fraction of Organic Material Converted to Methane	.24

Table 5 describes the variables and assumptions used to calculate Tajiguas methane production.

A 50-acre well field was chosen, because other methane well fields are about the same size, and because only parts of Tajiguas would be available at any one time. Landfill areas will be brought into production or depleted at various times, so only part of the landfill can be tapped. A 50-acre well field at Tajiguas could produce methane at a rate of:

$$\text{Production} = 181{,}106 \ \frac{50(150)}{130^2} = 80{,}372 \text{ cfd}$$

Gas cannot be produced indefinitely at this rate. Gas production drops as the organic content of landfilled waste is reduced by bacterial digestion. The productive life of a well can be expressed as:

$$\text{Lifetime (years)} = 2.49\ (10^{-3})\ (CR^2)$$

Using the variable values given in Table 5, the lifetime of a production well at Tajiguas would be:

$$\text{Lifetime} = 2.49\ (10^{-3})\ (.24)\ (130^2) = 10.1 \text{ years}$$

Raw methane gas is not generally usable as it comes from the wellhead, although electricity generation from combustion of raw landfill gas is being studied. The chemical impurities in raw methane gives it a lower heating value than natural gas (400 BTU/scf vs. 1,000 BTU/scf) as well as higher potential air emissions. If all impurities are removed from the methane, it's heating value can be raised to that of natural gas. Purification allows more complete combustion of the methane, so processing can produce a greater volume of gas at a higher heating value than what was withdrawn from the landfill. The state Solid Waste Management Board estimates that 5 scf of natural gas equivalent (960BTU/scf) can be produced from 1 scf of raw landfill gas. A 50-acre field at Tajiguas could therefore produce 401,860 scf of processed gas at 960 BTU/scf.

Mountain View determined that processing raw methane to the heating value of natural gas was prohibitively expensive - about $1.93/million* BTU for gas purification alone. If the methane were partially purified to a heating value of 700 BTU/scf, processing costs drop to $ .62/million* BTU. Gas volume also decreases, but not by as much as processing costs (no specific estimate available). Therefore, the Mountain View gas is

*1976 dollars

purified to 700 BTU/scf and sold to PG&E. PG&E can absorb the low BTU gas into its supply system without reducing the heating value of its gas, because the landfill gas is diluted in a much higher volume than regular natural gas. The Mountain View experience forms the basis of the recommendation that Santa Barbara County sell gas produced at Tajiguas to Southern California Gas Company.

Appendix D

SOLAR ENERGY

Solar Climatic Data for Santa Barbara County

The following tables are solar and climate date for Santa Barbara. Solar radiation figures are for 34° North latitude. Climate information is for various locations within the county.

Table I is the solar heat gain through a single-glazed, south-facing collector tilted up from the horizontal at 30°.

Table II is the same data except that the tilt is 45°. Both of these tilt angles are excellent for year-round water heating. As the tables show, the different tilts optimize gain for different months.

Table III provides solar gain for vertical south-facing single glazing. This data is appropriate for calculating space heat potential of direct gain windows and indirect systems. For double-glazing, reduce these figures by 12%.

Table IV describes the average daily percent of actual sunshine (PA) for each month. A day is considered clear if overcast conditions exist for less than 40% of the day. PA data must be compared to daily radiation data (Tables I, II, III) to ascertain the actual heat gain compared to potential heat gain.

Table V describes the heating degree-days for the months of October through March. Degree-days are a standard measurement used to profile temperature conditions for various locations. Degree-days indicate the number of degrees the average daily temperature goes below the base temperature of 65°F. Thus an average daily temperature of 46° amounts to 19 degree-days. An average temperature of 70° amounts to 0 degree-days.

Table VI describes average daily temperatures for the months of October through March at various county locations.

Table I: Solar Heat Gain Through Single-Glazing, South-Facing at 34°N; Collector Tilt = 30°.
(Btus/sq. ft/day)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1719	1985	2138	2138	2096	2060	2065	2083	2053	1923	1694	1593

Table II: Solar Heat Gain Through Single-Glazing, South-Facing at 34° N; Collector Tilt = 45°.
(Btus/sq. ft./day)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1906	2096	2116	1965	1821	1746	1788	1906	2030	2024	1875	1803

Table III: Solar Heat Gain Through Vertical South-Facing, Single-Glazing at 34°N
(Btus/sq. ft./day)

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1694	1596	1232	775	545	487	538	749	1186	1528	1658	1686

(Source, Tables I,II,III: ASHRAE, Handbook of Fundamentals

Table IV: Mean Percentage Possible Sunshine, Monthly

Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
65%	72%	70%	65%	60%	65%	70%	75%	78%	70%	70%	65%

(Source: Climatic Atlas of the United States)

TABLE V

SANTA BARBARA COUNTY MONTHLY DEGREE-DAYS
(HEATING SEASON OCT-MAR)

	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
Santa Ynez(1) Valley	74	210	355	396	336	335	1706
Lompoc (2)	133	241	375	372	325	323	1769
Santa Barbara-Goleta (3)	90	233	367	392	320	308	1710
Santa Maria (4)	152	269	416	425	365	378	2005

Sources:
1. U. S. Bureau of Reclaimation
2. Lompoc Water Treatment Plant
3. National Weather Service
4. National Weather Service

TABLE VI

AVERAGE DAILY TEMPERATURE

	OCT	NOV	DEC	JAN	FEB	MAR	AVERAGE
Santa Ynez Valley	62.1	58	53.5	52.2	53	54.2	55.5
Lompoc	60.7	57	52.9	53	53.4	54.6	55.3
Santa Barbara-Goleta	62.1	57.2	53.2	52.4	53.6	55.1	55.6
Santa Maria	60.1	56	51.6	51.3	52	52.8	54

Sources: See Table V

Passive Space Heating Systems

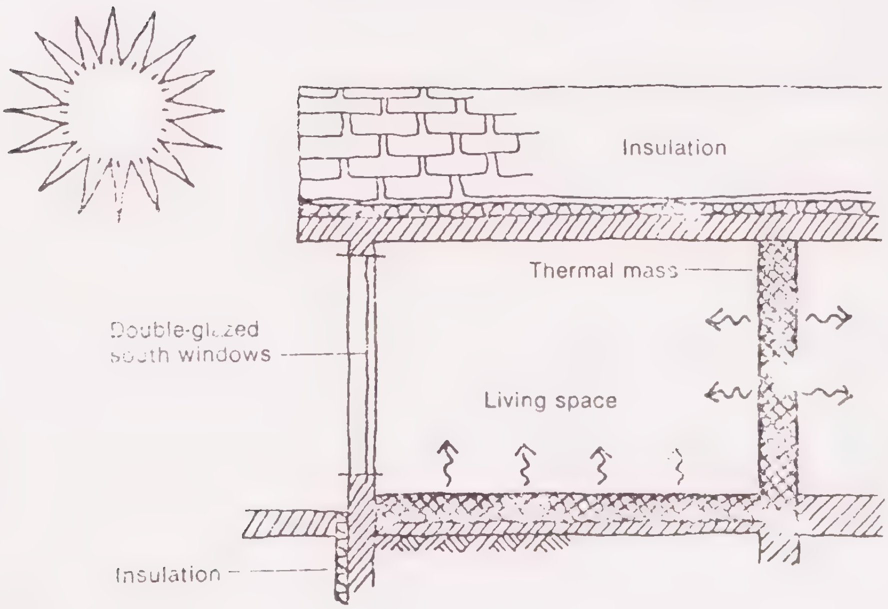
This section describes the better known approaches to passive space heating systems. Three generic types are considered: Direct gain systems, indirect gain systems, and attached greenhouse/sunrooms.

A. Direct Gain

The simplist form of passive solar house uses a large expanse of south-facing glass as a means of collecting solar energy. Each square foot of vertical south-facing glass will absorb between 1200 and 1700 Btus during the various months of the heating season (October through March) in Santa Barbara County. A 2000 sq. ft. house using approximately 300 sq. ft. of south glass can gain between 50 and 85 percent of its space heating requirements.

Figure 1.

Direct gain



Direct gain windows can be easily integrated into existing construction practices. Savings accrue because each square foot of glass replaces an equivalent amount of wall component material. The large amount of glass requires that the optimum floor plan be oriented along an elongated east-west axis. For best heat distribution, most rooms should be adjacent to the south wall. Open floor plans which minimize walls also aid in heat transfer.

Direct gain windows will gain much more heat in the day time than is likely to be needed. This can lead to wide temperature swings and overheating during the day.

Excess heat can be absorbed and stored in masonry or contained water. This "thermal mass" will absorb excess heat, moderate temperature and act as a "heat battery" to provide heat during the night or when overcast conditions prevail. A large thermal mass can provide several days of heat storage, depending on size and temperature conditions. Mass can be placed inside the building (water containers of various sorts) or can be part of the building's structure (adobe or masonry walls, deep floor slabs or tile floors).

Insulating a direct gain house is first priority. All thermal mass should have an insulating layer separating the mass from the outside air. This is best accomplished by insulating all exterior walls on their <u>outer</u> surfaces.

Thermal mass can also be built into room dividers, masonry fireplaces or in a number of other ways which can be decorative or disguised.

All windows should be equipped with moveable insulating shutters or drapes to control night-time heat loss. Overhangs to shade the windows during the warm months aid in cooling, as does a properly designed ventilation system.

A properly oriented and insulated direct gain house can provide 70% of the annual space heat requirements in Santa Barbara County. This can be accomplished by using an equivalent of 17% of the floor area for south-facing windows. Construction practices are conventional except that the framing or masonry on the south wall

is largely replaced with glazing. Thermal mass for storage can be provided by excavating below grade, laying down insulation, one to two feet of gravel, and pouring a conventional slab on top of this.

Direct gain designs will increase the cost of a house between $.50 and $1.50 per square foot of floor area. The price range reflects differences in house sizes and amount of heating load provided by the solar system.

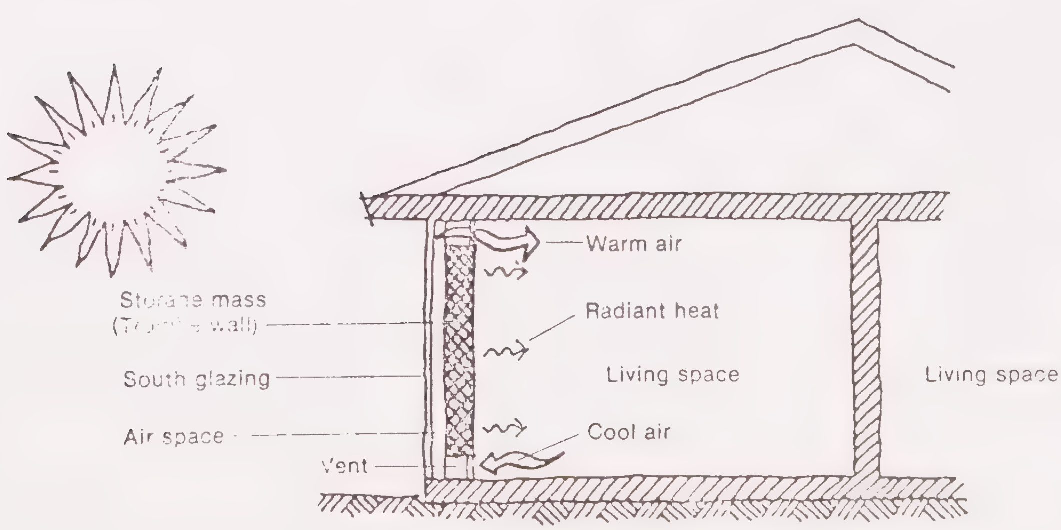
A 2000 sq. ft. house with about 325 sq. ft. of south facing double glass, heavily insulated surfaces and with thermal mass provided by a one-foot thick gravel and concrete slab will add about $2000 to the price of a house. If properly oriented and designed, this type of house will require only 25% of the conventional energy of a similarly sized house built to current standards. Solar tax credits will reduce this additional cost to $900.

B. Indirect Gain (Thermal Storage Wall)

Indirect gain systems utilize a thermal storage wall located next to a glazed surface and <u>between</u> the living space (see Fig.2). An air space, between one and four inches thick, separates the wall from the glazing. Additionally, there are vents located near the top and bottom of the wall. These vents allow cool air to pass from the living space up through the air space and to reenter the room at a higher temperature.

Figure 2

Thermal storage wall



During the daytime, sunlight passes through the glazing, warms the air in the air space, strikes and is absorbed by the thermal wall. During the night or periods of cloudiness, stored heat radiates from the wall into the living space.

The effectiveness of a thermal storage wall depends on three factors:

- The size of the wall, both its surface area facing the sun, and its total volume.
- Materials used in the wall; most fall into two categories: masonry or water.
- Measures taken to insulate the storage wall from night-time and cloudy day heat losses.

The thermal storage can be constructed of masonry or water. Common brick, concrete, cinder blocks or adobe are common materials. These walls are commonly called "Trombe Walls" after the French researcher, Dr. Felix Trombe, who has experimented extensively with indirect gain walls. One main advantage to masonry storage is that the wall can serve as both a structural part of the building envelope and as the solar heat storage system.

Water possesses excellent heat storage properties. In fact a given volume of water will store more energy than an equivalent volume of masonry material. Water can be stored in a variety of ways. Drums, culvert pipe, fiberglass tubes, and even small glass or plastic jars have been stacked next to the glazed south wall for effective heat storage. Successful attempts to disguise water walls include fabrication of rectangular sheet metal containers which can be plastered or painted or special water bags which can be installed in between framing members.

The effectiveness of an indirect gain system will depend on the collection surface area and the total volume of the thermal mass. An appropriate "rule-of-thumb" for Santa Barbara County would be one square foot of collection area for every five square feet of living space. This will supply at least 70% of the annual heating load.

The thicker the mass, the larger its heat storage capacity. Recommended thickness for various materials are:

Adobe: 8-12 inches
Common brick. 10-14 inches
Concrete: 12-18 inches
Water: 6-10 inches

Larger mass helps to moderate temperatures. A thin wall tends to heat up quickly and pass the heat into the living space too rapidly, causing overheating. At night, the lack of mass causes the wall to cool down quickly. Temperature swings in excess of 35° can result. On the other hand, a wall of proper thickness can reduce fluctuations to less than 10 degrees. As a general rule, the greater the wall thickness, the less the indoor temperature fluctuations.

Certain features of direct gain can be incorporated into indirect gain. Additional mass can be built into floors, north walls, masonry fireplaces, etc. Sections of the thermal wall can be used for window areas that allow a view to the outside as well as provide for direct gain.

Construction costs will vary according to thickness, but 8 to 10 dollars per square foot of collection surface is reasonable. Actual costs will depend on the choice of material for the wall and whether the wall is part of the building structure.

For the same size wall and heat storage capacity, a water wall is <u>slightly</u> more efficient than a masonry wall because the water wall can absorb and radiate heat at a faster rate. On the other hand water walls cannot generally serve as load bearing walls, and containing the water in an aesthetically pleasing way is a major design problem. Most existing applications of water walls have used stacked 55-gallon drums or freestanding metal or plastic cylinders. These clearly have limited appeal. Public acceptance is likely to increase as innovation in containers comes about.

C. Solar Greenhouse/Sunrooms

Sunrooms combine many of the features of direct and indirect gain techniques. They also create additional living spaces which can be used for a variety of activities. Additionally, a solar greenhouse is one of the only effective passive heating systems that can be readily retrofitted to existing buildings.

Generally a solar greenhouse differs from a conventional greenhouse in that solar greenhouses incorporate thermal storage. Conventional greenhouses collect heat during the day-time -- so much that venting is often necessary -- but lose that heat at night. Auxiliary heating is necessary if the interior temperature is to be maintained.

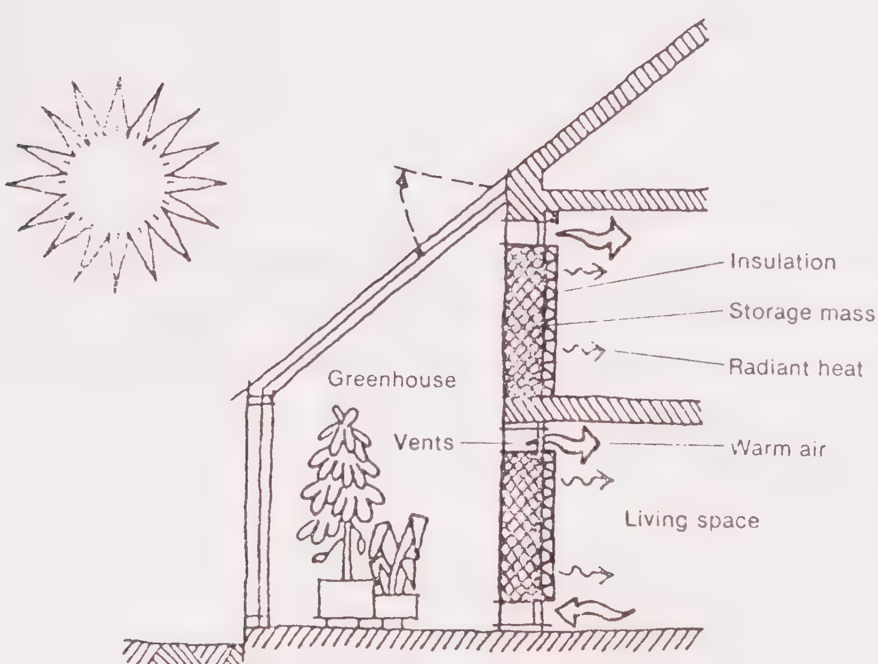
By incorporating thermal mass, heat can be stored. This keeps the greenhouse warm, and supplies heat to the rest of the living space. The back (or north) wall of the sunroom is the most appropriate space for mass, which can be masonry or contained water. Additional mass can be added to the floor.

Material costs for an attached sunroom can vary between 5 and 10 dollars per sq. ft., depending on the type of glazing and the amount and type of thermal storage mass.

Existing homes with unobstructed southern exposures are well suited for a sunroom retrofit.

(Figure 3)

Attached Greenhouse/Sunroom



Many homes, especially in low-rise subdivisions, can take advantage of this retrofit potential. A small greenhouse addition, unlike the construction of a complete house, is a project well within the capabilities of many "do-it-yourselfers." A ten-by-twenty foot greenhouse addition will absorb enough energy to provide in excess of 50% of the annual heating load for a 1500 sq. ft. house.

Even with large amounts of mass, a solar greenhouse can still overheat. Venting becomes very important in the greenhouse. Excess heat, especially in the warmer months, can be easily removed with vents located high in the greenhouse. This venting system can aid in summer cooling for the whole house. As heat is drawn out of the green house, heat from the rest of the house will move into the greenhouse and out through the vents. Two key elements of sunrooms are shading during the summer, and methods for reducing heat loss during the winter. Shading can be accomplished by using fixed or moveable overhead shades. These shades should be designed for the <u>late</u> summer sun, rather than for June 21, when the sun is at its highest in the sky. Ideally, shades should provide optimal shading during late August, the warmest time of the year. On a vertical glazed surface at 34° latitude, an overhang should extend beyond a window a distance equal to one-third the height of the window. For greenhouses using glazing on horizontally-inclined surfaces, shading must be directly over the glazing, because of the angle that the sun's rays strike the window.

Deciduous vegetation can also shade a sunroom or any other south-facing vertical collection surface. This vegetation can take the form of trees, scrubs or vines grown on an overhead trellis.

Insulating a greenhouse is especially important. East and west walls are best insulated rather than glazed. The south glazing should be fitted with insulating shutters or shades if the greenhouse space is to be kept warm at night. Alternately, the side of the storage wall <u>facing</u> the sunroom can be fitted with moveable insulation. This insures that the bulk of the stored energy will flow into the living space.

Solar greenhouses/sunrooms are attractive for a number of reasons. They are relatively inexpensive and can provide a large fraction of the required space heat. They can be retrofitted to many existing structures. They are a practical do-it-yourself project. Finally, solar greenhouses/sunrooms, unlike any other solar heating system, provide the user with additional living space.

Thermal Performance of a Passive House in Santa Barbara County

The 1978 energy efficiency standards to Title 24 will result in significant energy performance improvements in residential buildings. Specifically, these standards effect three areas of change for residential buildings in Santa Barbara County (i.e.,a less than 300 degree-day climate):

1. Ceilings must be insulated to R-19
2. Walls must be insulated to R-11
3. Glazing area must be no greater than 16 percent of gross floor area.

Using standard ASHRAE methodology for calculating heat loss (this includes a minimum design temperature of 34°F and an indoor comfort temperature of 68°F). A residence built to Title 24 standards will exhibit an overall heat loss factor of about 14 Btus/sq.ft./hr at a Δt of 34°F.While this is a good level of energy conservation, a further 20 percent reduction of heat loss, can be reached through the following changes:

1. Ceilings insulated to R-28
2. Walls insulated to R-19
3. Floors insulated to R-11

The requirements to Title 24 are energy conservation standard geared to reduce heat loss. Title 24 is not specifically concerned with heat gain, i.e., the use of passive solar as part of the architecture, design and construction of buildings. The only exception to this is the provision in Title 24, which exempts glazing oriented within 22½ degrees of true South from the 16% glazing restriction.

South facing vertical glazing is a net energy producer. At any location within the latitudes of the continental United States, this glazing will account for more gain than loss. This high loss

factor (V=1.1) <u>can be significantly</u> reduced through the application of night-time insulating shutters or curtains.

Passive solar design is generally accepted as the most cost-effective application of solar space heating in new buildings. There are a number of generic type of passive systems, some of the most common being direct gain through with windows and skylights, Trombe walls, "water walls", roof ponds and attached solar greenhouses. The choice of a specific passive design must take into account the following factors:

1. Site orientation and solar access.
2. Acceptability of architecture/aesthetics
3. Economic factors
4. Adaptability to conventional building materials and methods

No single passive approach is likely to optimize all of these factors, especially the aesthetic dimension. However, it can be demonstrated that a passive house can be constructed whose requirement for conventional energy will only be 25 percent of a house built to Title 24 specification. This can be accomplished by reducing heat loss approximately 20%, and by supplying approximately 70% of space heating through passive solar gain.

Many passive house systems can accomplish these levels of performance. It is possible and technically feasible to propose a County solar ordinance which would set performance standards on new housing requiring a heat loss level of less than 12 Btus/hr/s f^2 and an annual solar heating contribution of 70 percent. In the following calculations, a comparison is made between a house performing to these standards and a house built to existing Title 24 requirements. The significant features of this passive house are:

1. It is a "direct gain system utilizing south facing glass as the solar gain surface. This glass totals 17% of the gross floor area.

2. The house is oriented on a long east-west axis with the length being 1.8 times the width.

3. Insulating values are significantly increased at all heat loss surfaces.

4. Thermal mass is provided in the floor through a combination of slab and gravel. This is done by excavating sufficiently below grade to accomodate the specified insulation, gravel and cement slab. This thermal mass will provide almost three days of heat storage during overcast periods.

5. The wall framing pattern is altered from 2 X 4 studs on 16" centers to 2 x 6's on 24" centers. The same amount of lumber board feet is used, structural load is not increased, yet a larger wall insulation cavity is created.

6. Conventional building materials are used throughout. A house of this design would not require the use of unfamiliar construction techniques.

COMPARATIVE THERMAL PERFORMANCE:
TITLE 24 and PASSIVE GAIN

HEAT LOSS

	Title 24 House	Passive House
Slab (ground contact area)	2014 ft^2 (38x53)	1980ft^2 (33x60)
Rear	(8x53)	(8x60)
Total wall area (net)	304	130
Insulation area (75% of net wall area)	228	104
Stud area (25% of net wall area)	76	26
Window area (includes 1 glass door)	100	330
Door area	20	20
Total	424	480
Front	(8x53)	(8x60)
Total wall area (net)	340	424
Insulation area	255	339.2
Stud area	85	84.8
Window area	64	36
Door area	20	20
Total	424	480
Side (1)	(8x38)	(8x33)
Total wall area (net)	256	228
Insulation area	192	182.4
Stud area	64	45.6
Window area	48	36
Total	304	264
Side (2)	(8x38)	(8x33)
Total wall area (net)	256	228
Insulation area	192	182.4
Stud area	64	45.6
Window area	48	36
Total	304	264
Ceiling	(38x53)	(33x60)
Insulation area (90% of floor area)	1812.6	1782
Truss cord (10% of floor area)	201.4	198
Total	2014	1980

THERMAL RESISTANCE OF MATERIALS USED

Component:	Title 24 House R-Value (for thickness listed)	Passive House R-Value (for thickness listed)
1. Floor/Foundation		
Poured concrete slab (4")	.32	.32
Air film (still, heat flow down)	.92	.92
Carpet with fibrous pad	2.08	
1½" river gravel (12")		1.20
Extruded polystyrene insulation		10.00
Total	3.32	12.44
2. Walls (insulation area)		
Vertical air film (15 mph wind)	.17	.17
Wood siding	.85	.85
Medium density insulating sheathing	1.14	1.22
Cavity insulation	11.00	19.00
Gypsum wall board	.45	.45
Vertical air film (still)	.68	.68
Total	14.29	22.37
3. Wall (stud area)		
Vertical air film (15 mph wind)	.17	.17
Wood siding	.85	.85
Sheathing	1.14	1.22
Wooden studs	(2x4) 4.35	(2x6) 6.87
Gypsum Wall Board (½")	.45	.45
Vertical air film (still)	.68	.68
Total	7.64	10.24
4. Ceiling (insulation area)		
Air film (still, heat flow up)	.61	.61
Gypsum wall board (½")	.45	.45
Insulation	19.00	28.00
Air film (still, heat flow up)	.61	.61
Total	20.67	29.67
5. Ceiling (truss cord area)		
Horizontal air film (still, heat flow up)	.61	.61
Gypsum wall board (½")	.45	.45
2x6 wooden truss cords	6.87	6.87
Horizontal air film (still, heat flow up)	.61	.61
Total	8.54	8.54
6. Doors (entry)		
Vertical air film (15 mph wind)	.17	.17
Solid hardwood door (13/4")	1.59	1.59
Vertical air film (still)	.68	.68
Total	2.44	2.44

	Title 24 House R-Value (for thickness listed)	Passive House R-Value (for thickness listed)
Windows		
Vertical air film (15 mph wind)	.17	.17
Architectural glass, single pane	1.10	
Insulating glass-double (½" air space)		1.72
Vertical air film (still)	.68	.68
Total	1.95	2.57

U-VALUES (1/R)

	Title 24 House	Passive House
. Floor/Foundation	R=3.32 U= .30	R=12.44 U= .08
. Walls	R=14.29 U= .06	R=22.37 U= .04
. Walls (stud area)	R=7.64 U= .13	R=10.24 U= .09
. Ceiling (insulation area)	R=20.67 U= .04	R=29.67 U= .03
. Ceiling (truss cord area)	R=8.54 U= .11	R=8.54 U= .11
. Doors	R=2.44 U= .40	R=2.44 U= .40
. Windows	R=1.95 U= .51	R=2.57 U= .38

Steady-State Heat Loss for 24 Hours (Q_{hl})

Design Temperature: 34°F

Inside Comfort Temperature: 68°F

Δ t: 34°F

		Title 24 House	Passive House
1. Qhl for wall (insulation area)	=	42448.32 Btus	26373.12 Btus
2. Qhl for wall (stud area)	=	30657.12 Btus	14834.88 Btus
3. Qhl for floor/foundation (*Δt based on average groundwater temp. of 55°F)	=	188510.40 Btus	50269.44 Btus
4. Qhl for ceiling (insulation area)	=	59163.26 Btus	43623.36 Btus
5. Qhl for ceiling (truss cord area)	=	18077.66 Btus	17772.48 Btus
6. Qhl for windows	=	108201.60 Btus	135815.04 Btus
7. Qhl for doors	=	13056.00 Btus	13056.00 Btus
Total Qhl (1-7)		460,114.36 Btus	301,744.32 Btus

INFILTRATION HEAT LOSS (Qi)

Method: Air Exchange

Air Changes/Hour, overall: 1

Qi =	236653.06 Btus	232657.92 Btus
Total heat loss (Qhl + Qi) =	696767.42 Btus	534402.24 Btus
Loss in Btus/ft^2/hr at 34°FΔt =	14.41 Btus	11.24 Btus

LOSS CORRECTED FOR AVERAGE MINIMUM TEMPERATURE (Title 24)

	Min. Temp.	Δt		
JAN	41°F	27	553315.30 Btus	424378.25 Btus
FEB	43°F	25	512328.98	392942.75
MAR	43°F	25	512328.98	392942.75
OCT	51°F	17	348383.70	267201.07
NOV	45°F	23	471342.66	361507.33
DEC	43°F	25	512328.98	392942.75

DIRECT GAIN THROUGH SOUTH-FACING GLASS

Gain (Btu/ft^{O}/day)	Percent Actual Sunshine	Window Area	Shading Coefficient	System Efficiency	=	Daily Gain (Btus)
1687	.68	330	.87	.80		263479.7
1620	.67	330	.87	.80		249294.6
1288	.68	330	.87	.80		201162.9
1550	.70	330	.87	.80		249202.8
1651	.76	330	.87	.80		288193.2
1660	.71	330	.87	.80		270700.8

SOLAR CONTRIBUTION OF 330 FT^2 SOUTH-FACING GLASS, CORRECTED FOR HEAT LOSS BASED ON AVERAGE MINIMUM TEMP.

	Min. Temp.	Δt	Q	% Contribution
JAN	41°F	27	424377.9	62%
FEB	43°F	25	392942.5	63%
MAR	43°F	25	392942.5	51%
OCT	51°F	17	267200.9	93%
NOV	45°F	23	361507.1	79%
DEC	43°F	25	392942.5	68%

Gain (Oct - Mar)/Loss (Oct - Mar)

1,522,034 Btus/2,231,913.4 Btus = 68%

THERMAL MASS STORAGE CAPACITY

1. Component: 4" concrete slab
    a. Volume: 660 cu. ft.
    b. Density: 150 lbs/cu. ft.
    c. Specific heat constant: .23 Btus/lb/of
    d. Heat capacity, 15°F rise: 341550 Btus

2. Component: 1 ft. ungraded river gravel
    a. Volume = 1584 cu. ft.
    b. Density = 165 lbs. cu. ft.
    c. Specific heat constant: .21 Btus/lb./°F
    d. Heat Capacity, 15°F rise: 823284 Btus

3. Total Storage Capacity: 1164834 Btus

4. Days of Storage (carry over) at 65°F: 2.4 days

Some features of this comparison should be noted. Other heat loss analysis methods (such as an hour-by-hour computer simulation) can be used, but the relative performance of the two structures will remain the same. Window heat gain on the conventional Title 24 house cannot be computed since there is no way to insure orientation, window placement, or vegetation control.(The last factor can affect shading.) In the case of the passive house, these factors are controlled and can therefore be computed. Full insulation of the floor component in the passive house is advised. In a conventional house, perimeter slab insulation may be sufficient. In the passive house, the floor component (gravel and slab) serve as a heat sink (thermal mass). As such, these mass operate at significantly higher temperatures than a conventional slab. Thus, heat loss through this surface will be great enough to warrant full insulation. Finally, the direct gain window area equals 17% of the gross floor area. In practice, the Santa Barbara area climate makes it possible to reduce window area to as little as 11%. (Mazria, Passive Solar Handbook, 1979).

The net costs for a passive house must be calculated with a number of factors in mind. First every square foot of south facing glazing replaces the wall component materials that would have been used otherwise. This reduces double-glazing costs by at least 25%. Second, the conventional heat system may cost $1,600 installed.

In its place a series of gas wall furnaces could be used for back up. Three double register gas wall furnaces will cost approximately $750 installed. These savings, plus federal and state tax credits may actually reduce the construction costs of the house. For this analysis it is assumed that the passive features will add $2,000 (or $1.00/sq. ft.) to the cost, before tax credits.

This example house serves to show that future construction can take advantage of many common materials and techniques as a way to incorporate passive solar and increased energy efficiency. As stated earlier, many other design options exist beside the cited example. Given these options, it is reasonable to expect that passive solar can be made compatible with a wide variety of new construction differing in style, cost, and materials.

SOLAR WATER HEATING

Of all the uses of solar energy, the solar water heater is the most common and widely used. Solar water heating is attractive because it can be easily utilized in both retrofit and new home construction. Because hot water demand is almost constant throughout the year, a solar water heater can be used at all times.

Solar water heating technology has been used throughout the world for one hundred years. Solar water heaters were common in Florida and southern California in the early 1900's. Many current systems are similar in design to their antecedents, and many new approaches, resulting in vastly improved levels of efficiency, have been made.

Two basic approaches to water heating have developed. The first is passive, and includes two sub-types: batch (or integral storage) and thermosyphon systems. These two types are distinguished by the fact they require no pumps, controls or automatic valves as part of the system. Hence they require no conventional energy (except for back-up) to power them.

The second generic type is the active system. This type is also divided into two sub-types: the direct (or potable water) system, and the heat exchanger system. Both of these sub-types require some electrical power to operate pumps, valves and controllers that are a part of these systems. Active systems represent the most highly developed and efficient of all solar water heaters. However, the price of a professionally designed, manufactured, and installed active system begins close to 2000 dollars. Such a system should provide at least 70% of the annual water heating energy. At the other end of the scale, a batch system will provide about 35-60% of the water heating energy. However the cost of such a system can be well under 100 dollars. If we attempt to measure the value of a system by the amount of energy it delivers for each dollar it costs, the batch system is the most attractive. If a system is measured by its convenience, overall fraction of energy supplied, and adaptation to existing buildings and lifestyles, active systems appear more attractive.

A. Batch Systems

Batch systems are the oldest and simplest of all solar water heaters. They combine collection and storage functions in one unit. They are normally plumbed in series with the existing water heater. As water is consumed in the household, water pressure in the lines automatically refills the batch unit.

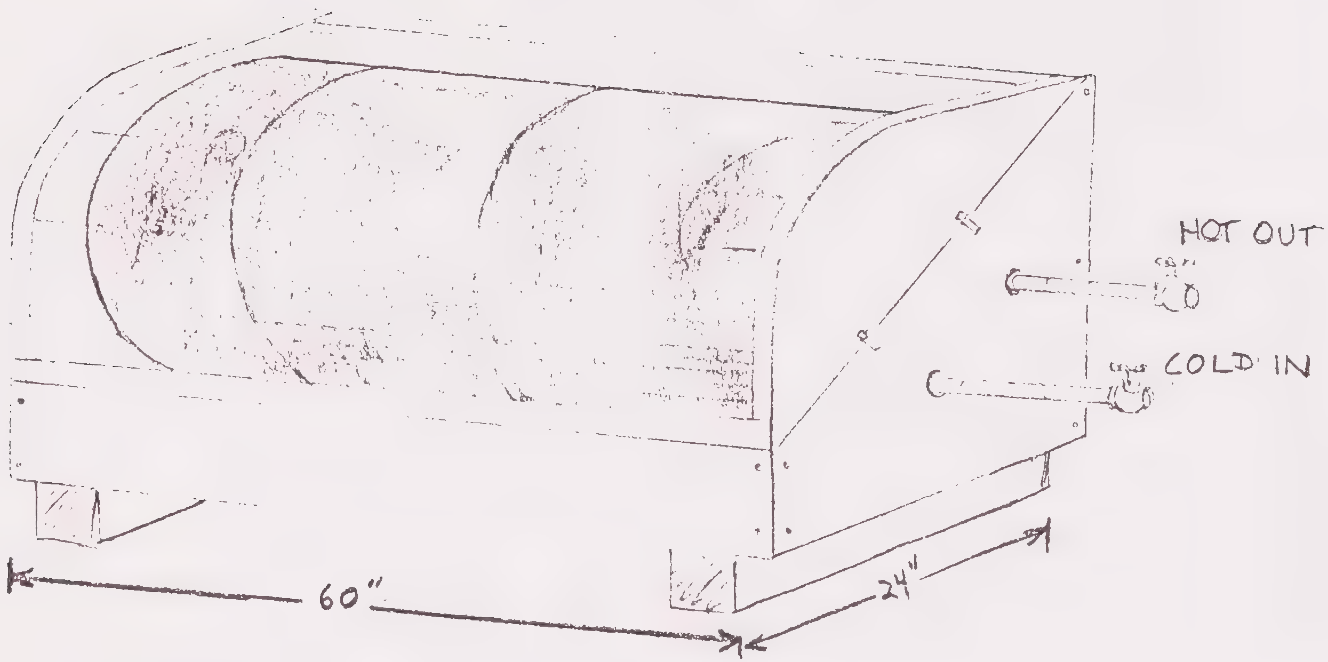
Batch units are often known as "breadbox" heaters because of the resemblance of the unit to a breadbox. A water tank is placed inside a glazed and insulated container. When properly oriented a breadbox heater can raise water to 140°F. On a clear winter day the heater should raise temperatures approximately 50 degrees above incoming water temperature. It is important to place an insulated cover over the glazing at night to prevent heat loss. With a cover having an "R" value of 11 or better, the tank will lose ten to twenty degrees during the night.

The Community Action Commission of Santa Barbara, Inc., is currently conducting extensive testing of breadbox designs. The CAC design uses a water heater tank core as the storage vessel. Cost of the system is as follows:

60-gallon tank core (new)	$ 90
Insulation material	13
Wood	24
Glazing	12
Night cover	20
Misc. hardware and materials	12
TOTAL	171

These costs exclude labor and installation materials ($15-30). The use of recycled materials can reduce the price almost by one-half. Old water heaters often have sound cores. These tanks can be stripped, tested, cleaned and painted, and will be as serviceable as a new tank. Old heaters can be obtained from plumbing contractors for under five dollars. A properly built and installed breadbox is fully eligible for the State Solar Tax Credit, thus bringing the cost to well under $100.00.

Figure 4



The average single family household in Santa Barbara uses about 26 million Btus (260 therms) annually for basic water heating needs. A breadbox supplying only 45% of this energy would contribute 11.7 million Btus. A $100 breadbox would supply 117,000 Btus for every dollar of the system's initial cost.

As a comparison, an active flat-plate water heater costing $1800 will actually cost the user 810 dollars after tax credits. If this system provides 70% of the water heating energy, it will contribute 18.2 million Btus, or 22469 Btus for each dollar of the system's cost. Thus, the breadbox supplies more than five times the energy per dollar cost.

For all this, the breadbox has some disadvantages. For some people, the manual open and closing of the night cover is an inconvenience. This can be overcome by the use of a motorized cover and control unit. Automating the unit may add $50 to the price.

Another disadvantage is the slow heat-up and recovery time of the breadbox. The heater may not reach peak temperatures until the late afternoon. If the water demand is not regulated, the breadbox will have trouble responding. Ideally the user should use hot water in the evenings and the mornings. This allows the unit to heat up with least disturbance during the sunny hours. For households where the members are away at work or school, this should require little change in living patterns.

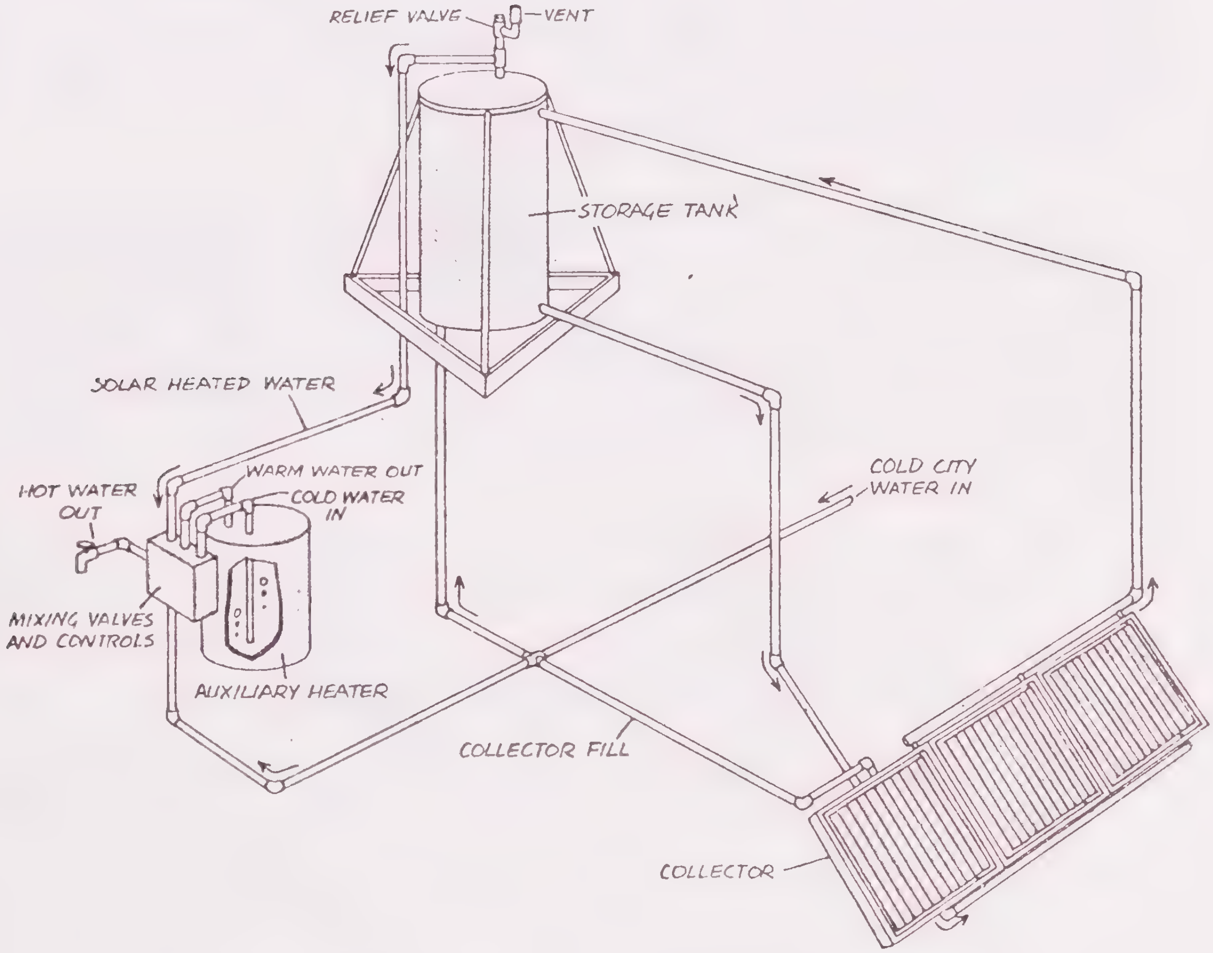
Finally, batch systems generally are not production items. The majority of batch systems are owner-constructed. This of course is an advantage for those who are inclined to build their own, but a disadvantage to those who would like a low-cost system but do not choose to construct their own unit.

B. Thermosyphon Systems

The second type of passive system is the thermosyphon type. These units have two major components: a flate-plate collector and a storage tank. Thermosyphon systems are so named because they take advantage of the natural phenomenon of heated water rising and cooler water falling. The storage tank is mounted

at least 18 inches above the top of the collector. A plumbing

Figure 5



The thermosiphoning solar water heating system

loop connects the top of the collector to the top of the tank, and the bottom of the collector to the bottom of the tank. As the water in the collector is heated by the sun, it creates a flow condition and passes to the top of the storage tank. The denser cooler water in the storage tank flows into the bottom of the collector, completing the circulation loop.

This natural heat flow is a gentle, relatively slow process. The process can be restricted or stopped unless extreme care is taken in plumbing the system. The lines should not have any kinks or dips. Pipes should be at least 3/4 inches diameter.

Costs for a thermosyphon system will vary, but the following is a reasonable guideline:

Single-glazed collector @ $15/sq. ft, 50 sq. ft.	$750
66-gallon hot water heater (storage w/back-up)	175
Misc. plumbing, hardware, etc.	50-150
8 person-hours labor	160-200
TOTAL	1135-1275

The main problem with thermosyphon systems is the difficulty in finding a proper location to mount the tank above the collector. Special structural consideration must be given to the tank because of its weight (66 gallons of water weigh 550 lbs.). If the collector is mounted at ground level, the tank can be placed on a structure above it. If access and space is available, the collector can be mounted in the attic. This is especially feasible in new construction.

Collectors in a thermosyphon system require protection from the danger of an occasional freeze. The only method which does not require auxiliary power utilizes manual drain valves. Heating tape or electrical valves can be used but they require outside energy. Also they add to the cost of the system; perhaps $100-150.

C. Direct Systems

Direct systems are a common type of active solar water heater. They are also called "open" or "potable water" systems. City water runs throughout the system, is heated directly in the collector, and transferred for storage and use.

Unlike a thermosyphon system, the collector can be placed in any location relative to the storage tank. Water is moved through the system via a small electric pump, normally in the range of 1/20-1/12 horsepower. A special temperature sensing unit--called a differential controller--operates the pump. When the collector is a certain amount hotter than the storage tank (normally about 10° difference), the controller turns on the pump and water is circulated between the collector and the tank. This process continues until the storage tank reaches the same temperature as the collector.

Open systems can employ one or two tanks. In a two tank system, water from the collector is stored in the first tank and then moves

into the second tank. The back-up system is contained in the second tank. The back-up should be either natural gas or LPG, since they are more cost-effective than electrical water heating. One tank systems combine storage and back-up in one tank.

According to the Pacific Regional Solar Heating Handbook, two tank systems are more efficient than one tank systems. Since back-up heat is supplied to the second tank, the solar portion can operate at a lower storage (and collector) temperature, and thus at a higher heat collection efficiency. This is more important in cold climates where there is a large temperature differential (above 100°F) between the ambient air temperature and the desired water temperature. In Santa Barbara, this differential rarely exceeds 70°F during collection hours.

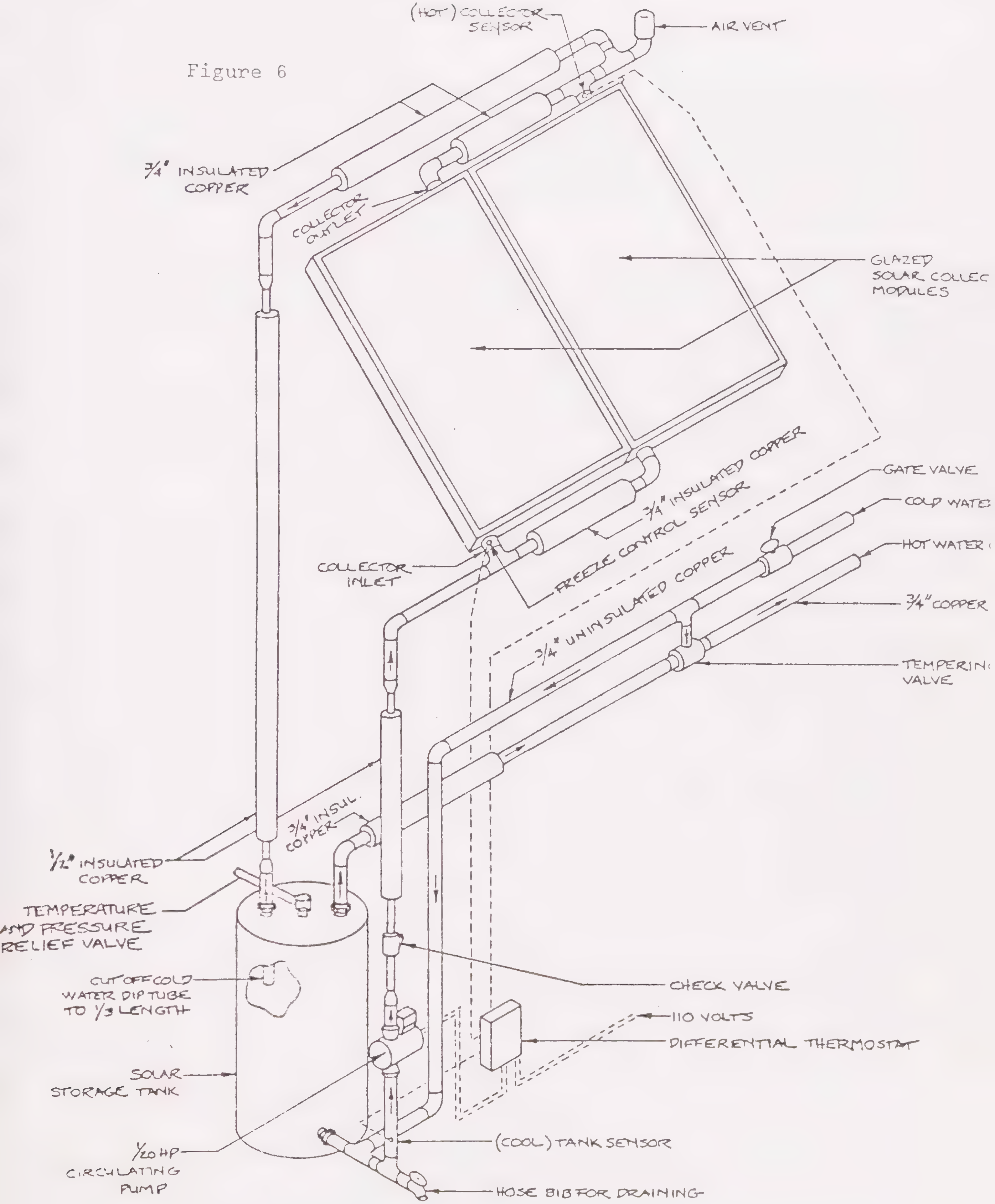
Secondly, a two-tank system adds to the cost of the system. An additional storage tank, piping, valves, etc. can add 150 to 300 dollars to the system price. Adding a second tank does give an overall increase in the amount of hot water in the system.

An important aspect of an open system is the provision of freeze protection in the collector. Even in coastal areas, freezing is likely to occur sometimes during the winter months. On a very clear winter night, night sky radiation can cause a collector to freeze even with the air temperature in the high 30's.

Two types of freeze protection are used: drain-down (or dump) systems and recirculation systems. Figure 6 illustrates a recirculation system. This system uses a sensor in the collector to monitor the occurrence of freeze conditions. If temperatures reach 38°F, the sensor signals the controller to operate the pump. A small amount of hot water from the storage tank circulates through the collector, warming the waterways. When the collector reaches 40°F, the pump is turned off. While a small amount of collected energy is wasted in keeping the collector warm, this is a sensible approach in areas where freeze conditions are rare.

The second method, drain down, uses electrically controlled solenoid valves to empty water from the collector if freezing is imminent. Again, a sensor is used to detect freeze conditions. When freezing

Figure 6


(HOT) COLLECTOR SENSOR
AIR VENT
3/4" INSULATED COPPER
COLLECTOR OUTLET
GLAZED SOLAR COLLEC MODULES
3/4" INSULATED COPPER
FREEZE CONTROL SENSOR
GATE VALVE
COLD WATE
HOT WATER
3/4" COPPER
COLLECTOR INLET
3/4" UNINSULATED COPPER
TEMPERIN VALVE
3/4" INSUL. COPPER
1/2" INSULATED COPPER
TEMPERATURE AND PRESSURE RELIEF VALVE
CUT OFF COLD WATER DIP TUBE TO 1/3 LENGTH
CHECK VALVE
110 VOLTS
DIFFERENTIAL THERMOSTAT
SOLAR STORAGE TANK
(COOL) TANK SENSOR
1/20 HP CIRCULATING PUMP
HOSE BIB FOR DRAINING

occurs, the solenoid valve opens and gravity drains water from the collector. Also, a power shortage will also cause the system to drain. This feature protects the system from freezing during power outages; the recirculation system does not offer this extra protection.

Drain down systems add $50-125 to the price of an active water system. Recirculation method does not appreciably add to the system cost.

D. Heat-Exchanger Systems

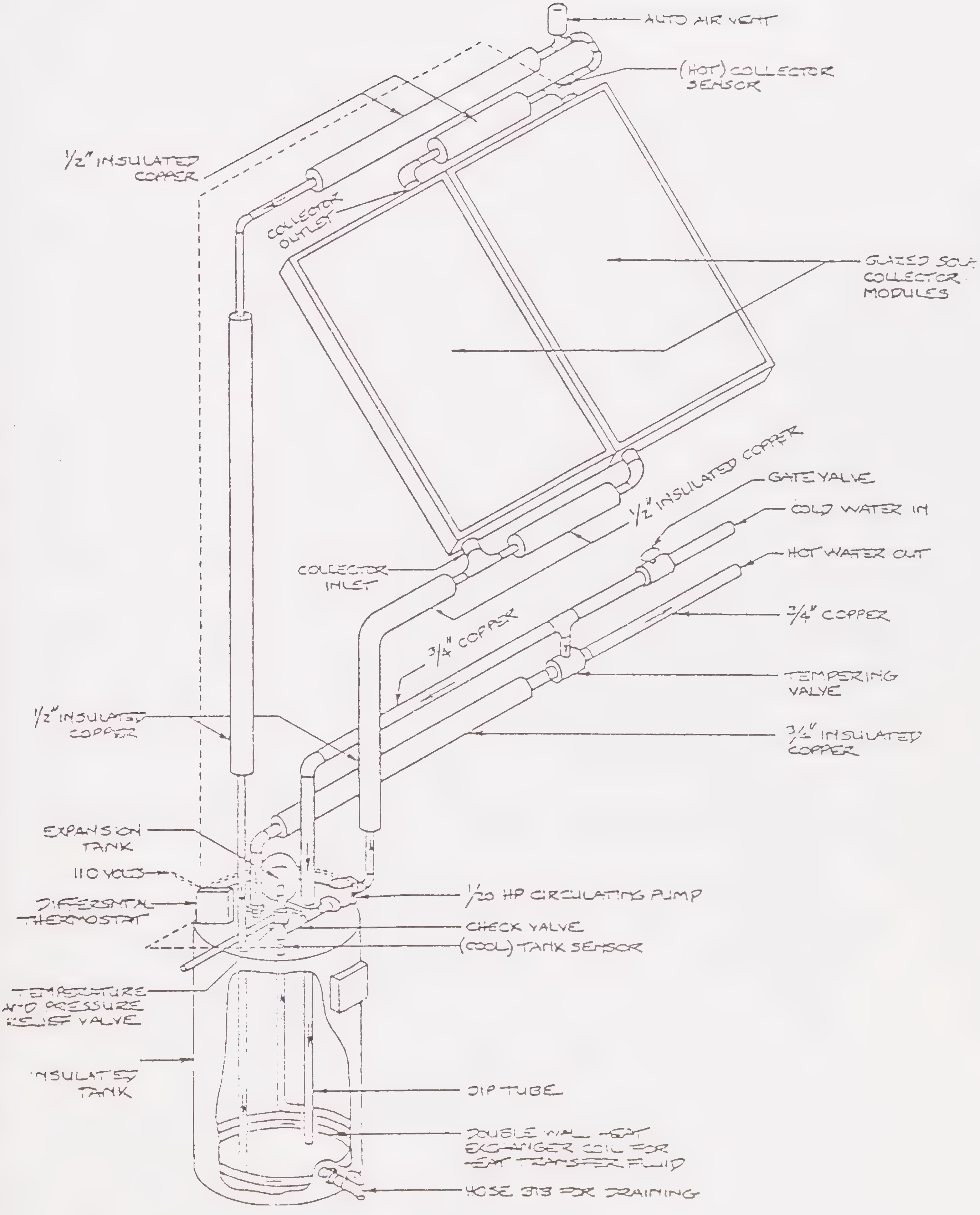
The most expensive and complex active system is the heat-exchanger type. It offers, for the extra money, total freeze protection and it also guards the system from the corrosive and destructive--effects of water in certain areas.

Heat from the collector is not transferred directly to water. Instead, a non-freezing and non-corrosive fluid transfers the heat to heat exchanger apparatus in the storage tank. This exchanger is normally a jacket around the tank or a coil of copper inside the tank. The heated fluid conducts the heat through the exchanger and into the potable water. From this point on, the system is parallel to an open system. One or two tank options.

The transfer fluid is normally an anti-freeze solution (often mixed with distilled water) similar to automobile anti-freeze. Depending on the mixture, it can withstand-40°F. Thus, the collector is completely protected from freeze damage.

Many local water systems have highly corrosive water. This water can clog up or deteriorate collector water passage ways. The use of the heat-exchanger system isolates this water from the collector. However, many anti-freeze solutions, themselves, will deteriorate and become acidic in one or two years. At that point, it must be replaced, or collector damage is likely. Many new transfer fluids have been developed which reduce this problem. Also, the use of a water softener will largely eliminate the corrosive effects of water, making an open type active system practical. Still, the heat-exchanger method offers the most effective freeze protection.

Most transfer fluids are at least somewhat toxic. If the exchanger leaked fluid into potable water, a health hazard would be present.


AUTO AIR VENT
(HOT) COLLECTOR SENSOR
1/2" INSULATED COPPER
COLLECTOR OUTLET
GLAZED SOLA COLLECTOR MODULES
1/2" INSULATED COPPER
GATE VALVE
COLD WATER IN
HOT WATER OUT
COLLECTOR INLET
3/4" COPPER
3/4" COPPER
TEMPERING VALVE
1/2" INSULATED COPPER
3/4" INSULATED COPPER
EXPANSION TANK
110 VOLTS
DIFFERENTIAL THERMOSTAT
1/20 HP CIRCULATING PUMP
CHECK VALVE
(COOL) TANK SENSOR
TEMPERATURE AND PRESSURE RELIEF VALVE
INSULATED TANK
DIP TUBE
DOUBLE WALL HEAT EXCHANGER COIL FOR HEAT TRANSFER FLUID
HOSE BIB FOR DRAINING

This can be eliminated by the use of a double-wall "fail-safe" heat exchanger. This type provides two separation walls between exchanger fluid and potable water. It is unlikely that both walls will leak and contaminate the water.

Heat exchanger systems are likely to cost in excess of $2,500. At the same time, they are less efficient (perhaps 10-15%) because the water is not heated directly. Every time heat is transferred from one surface or fluid to another, energy is lost. This can be compensated for by increasing collector size, but this again further increases system cost.

METHODS FOR SIZING SOLAR HOT WATER HEATING SYSTEMS

Calculating the appropriate size of the main components of a solar water heater is a straight forward task since hot water demand remains fairly constant throughout the year. Two methods will be discussed. The first method is a "fule of thumb" which uses some well established assumptions about key system size variables. The second method is a user-specific heat load computation.

Rule Thumb Method

This approach includes six assumptions:

The average daily per person use of hot water for hygiene, kitchen use and clothes washing is 20 gallons per day.

Collector tilt is equal to latitude $\pm$ 20°.

Collector orientation is within 22.5° east or west of true south.

Collector output is minimally 1.5 gals/sq. ft. of collector at 120°F.

Storage capacity is equal to 1.5 gals/sq. ft. of collector.

The above parameters will allow for a solar contribution of 75% of annual water heating energy.

The following is an example of this method:

1) Size of household: 4
2) Daily water consumption: 80 Gallons
3) Required collector size: 53.3 sq. ft.
4) Required storage: 80 Gallons

If a two-tank system is used the following changes need be made:

Collector output: 2 gals/sq. ft. of collector.

back-up (2nd) tank capacity: 1/2 storage tank size.

Example:

1) size of household: 5
2) daily consumption: 100 gallons
3) collector size: 50 sq. ft.
4) tank size: 75 gal. (storage) + 40 gals. (back-up)

Heat Load Calculation Method

A more site-specific calculation for a water heating system can be done once certain information has been gathered. This method is broken down into two areas:

1) Ascertaining the required amount of energy needed for supplying water at the required temperature.
2) Sizing an appropriate system to meet that load.

Heat Load requires the following information:

- o daily use in gallons.
- o temperature difference between incoming cold water and required service temperature.
- o storage loss (this is an assumed constant and amounts to 325 Btus/gal/day. Source: American Gas Association)

As an example, a four person household requires 80 gal./day. Incoming water averages 61°F in Santa Barbara. Service temperature is 120°F Temperature difference is 59°F. A gallon of water needs 8.33 Btus to raise its temperature 1°F. Thus in this example:

80 gals X 8.33 Btus X 59°F:	39317.6 Btus
Storage Loss (325 X 80):	26000.0 Btus
Total Heating Load:	65317.6 Btus

Sizing calculations require an estimation of the heating fraction provided by solar. In the rule of thumb method, above, a 75% fraction was used. This fraction amounts to 48988.2 Btus/day of the total heating load (.75 X 65317.6 Btus).

The second step is determining the amount of available solar energy for a particular location, and the ability of the solar system to convert and transfer that energy into water.

In Santa Barbara County, An annual average of 1962 Btus/ sq. ft./day falls on a collector oriented due south and tilted 30° up from the horizontal. Assuming the collector is rated at 50% overall efficiency. Each square foot of collector transfers 981 Btus/sq. ft./day. Line losses from collector to storage will average about 12%. This reduces the 981 Btus to 863.3 Btus. Thus, the water heating requirement can be fulfilled with:

48988.2 Btus/863.3 Btus per sq. ft. = 56.7 square feet.
Collector area: 56.7 sq. ft.
Storage: 85 gallons
Back-up Tank: 40 gallons

APPENDIX E

GLOSSARY OF TERMS

Absorber: The blackened surface in a collector that absorbs solar radiation and converts it to heat energy.

Active System: A solar heating or cooling system that requires mechanical power to move the collected heat.

Altitude: The angular distance from the horizon to the sun.

ASHRAE: Abbreviation for The American Society of Heating, Refrigerating, and Air-conditioning Engineers.

Azimuth: The angular distance between true south and the point on the horizon directly below the sun.

Collector Efficiency: The ration of heat energy extracted from a collector to the solar energy striking the cover, expressed in percent.

Cooling Load: The amount of energy required to cool a structure to a desired temperature. Usually calculated in BTU's/sq.ft.

Double-Glazed: Covered by two layers of glass or other glazing material.

Energy Recovery: Extraction of energy resources (gaseous, solid, or liquid fuels) from waste material (MSW or sewage).

Enhanced Oil Recovery: A method for extracting very heavy, thick crude oil by injecting steam into the wells.

Heat Exchanger: A device that is used to transfer heat from one fluid to another through an intervening metal surface.

Heating Load: The amount of energy required to heat a structure to a desired temperature. The heating load is typically calculated in BTU's/sq.ft.

Heating Season: The period from Oct. 1 to March 31 during which additional heat is needed to keep a house warm.

Heat Storage: A device or medium that absorbs collected storage heat and stores it for periods of inclement or cold weather.

Insolation: The total amount of solar radiation--direct, diffuse, and reflected--striking an exposed surface.

Life Cycle Cost: A method for evaluating the economic feasibility of energy equipment and local energy programs. Initial, operating, and replacement costs incurred over time by alternative projects are compared.

Low-Btu Gas: Is a biogas composed of Hydrogen, Carbon Monoxide, Trace Elements of Methane and other Hydrocarbons, and Nitrogen.

Municipal Solide Waste (MSW): All discarded material capable of being disposed in a Class II landfill. Hazardous industrial waste (e.g. chemicals) and liquid wastes, which require different disposal procedures, are not included.

Passive System: A solar heating or cooling system that uses no external mechanical power to move the collected solar heat.

Percent of Possible Sunshine: The percentage of daytime hours during which there is enough direct solar radiation to cast a shadow.

Photovoltaic Cells: Semi-conductor devices that convert solar energy into electricity.

Resource Recovery: Removal and re-use of recyclable material in municipal solid waste.

Retrofitting: The application of solar/conservation techniques to existing buildings.

Tilt Angle: The angle that a collection surface forms with the horizontal.

True South: Actual polar south. In Santa Barbara this is 15° east of magnetic south.